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اقرار والتزام بالمعايير الأخلاقية والأمانة العلمية وقوانين الجامعة الأردنية وأنظمتها وتعليماتها لطلبة الماجستير

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عنوان الرسالة:

Development of an assessment tool for the implementation of lean production principles in the Jordanian industries

تطوير أداة لتقييم مدى تطبيق مبادئ الإنتاج المرن و الكفؤ في الصناعات الأردنية

أعلن بأنني قد التزمت بقوانين الجامعة الأردنية وأنظمتها وتعليماتها وقراراتها السارية المفعول المتعلقة باعداد رسائل الماجستير عندما قمت شخصيا" باعداد رسالتي وذلك بما ينسجم مع الأمانة العلمية وكافة المعايير الأخلاقية المتعارف عليها في كتابة الرسائل العلمية. كما أنني أعلن بأن رسالتي هذه غير منقولة أو مستلة من رسائل أو كتب أو أبحاث أو أي منشورات علمية تم نشرها أو تخزينها في أي وسيلة اعلامية، وتأسيسا" على ما تقدم فانني أتحمل المسؤولية بأنواعها كافة فيما لو تبين غير ذلك بما فيه حق مجلس العمداء في الجامعة الأردنية بالغاء قرار منحي الدرجة العلمية التي حصلت عليها وسحب شهادة التخرج مني بعد صدورها دون أن يكون لي أي حق في التظلم أو الاعتراض أو الطعن بأي صورة كانت في القرار الصادر عن مجلس العمداء بهذا الصدد.

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DEVELOPMENT OF AN ASSESSMENT TOOL FOR THE IMPLEMENTATION OF LEAN PRODUCTION PRINCIPLES IN THE JORDANIAN INDUSTRIES

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This Thesis was submitted in Partial Fulfillment of the Requirements for the Master's Degree of Industrial Engineering

Faculty of Graduate Studies
The University of Jordan

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COMMITTEE DECISION

This Thesis/Dissertation (Development of an assessment tool for the implementation of lean production principles in the Jordanian industries) was successfully defended and approved on <u>28th April 2011, Thursday</u>.

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DEDICATION

"To Prophet Mohammad and his companions who laid the foundations of modern civilization and paved the way for social, moral, political, economical, cultural and physical revolution"

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LIST OF ABBREVIATIONS

TPS	Toyota Production System
LP	Lean Production
WIP	Work In Process
JIT	Just-in-Time
TQM	Total Quality Management
MET	Manufacturing Equipment and Technology
DFMA	Design For Manufacturing and Assembly
TPM	Total Productive Maintenance
PM	Preventive Maintenance
GT	Group Technology
VC	Visual control
BPR	Business Process Reengineering
RPA	Rapid Plant Assessment
LESAT	Lean Production Enterprise Self Assessment Tool
TQM	Total Quality Management
LM	Leanness Measure
DEALM	Data Envelopment Analysis Leanness Measure
ROI	Return On Investment
H	Hypothesis
SPSS	Statistical Package for the Social Sciences
CC alpha	Cronbach's alpha coefficient
χ^2	Chi- square
RMSEA	Root Mean Square Error of Approximation
DF	Degrees of freedom
CFI	Comparative fit index
ANOVA	Analysis of variance

DEVELOPMENT OF AN ASSESSMENT TOOL FOR THE IMPLEMENTATION OF LEAN PRODUCTION PRINCIPLES IN THE JORDANIAN INDUSTRIES

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ABSTRACT

International markets driven forces are changing continuously toward the needs of industrial companies to gain a competitive edge in such a market. Therefore, improving company's products, processes and practices is no longer auxiliary. Lean production implies many techniques that consolidate work tasks with minimum waste resulting in greatly reduced wait time, queue time, and other delays. Lean production can be mapped into many impact areas. One of these areas is Manufacturing Equipment and Technology (MET). Lean practices in such impact area are classified into six lean practices namely, specific equipment configurations, total preventive maintenance, visual control, new equipment/ technologies, production process reengineering, and shared vision of perfection.

The purpose of this study is to investigate the implementation level of these six practices in the MET are of Jordanian industries. Questionnaire has been designed according to five-point Likert scale. A pilot study was conducted for 25 companies and experts review to validate the questionnaire.

A sample of 209 Jordanian companies participated in the study. The participants were asked to rate the extent of implementation for each lean practices. A conceptual model was developed and hypotheses were empirically built, consequently statistical test was conducted. An assessment tool was designed to monitor progress and effectiveness of the companies' process improvement effort. Multicollinearity test analysis was conducted between all the questions of each latent of MET and the results were positive among all the questions. Test of reliability was conducted by Cronbach’s alpha. The overall MET model has a high Cronbach’s alpha value of 0.87 which is very good. The developed model fitness was checked using AMOS software and the results

obtained from this software included the chi-square method and RMSEA test.The results showed that the model is fit.

It has been found that the implementation level of lean practices in MET is 76.86%. It is concluded that many Jordanian companies are very good implementers of lean production practices. The lean production assessment tool model can be used to define the gaps in performance and point out areas of opportunity for breakthrough improvement in the company. The research provides a validated and tested assessment tool that help in improving progress and effectiveness of production processes improvement.

Chapter One
INTRODUCTION

A struggle for winning is between all countries and all sectors. It is assured now that winning and competition can be reached by companies and enterprises that can deliver the products at the lowest possible price with high quality. At the same time businesses should run in profit. This is possible by reducing the source of waste and introducing new technology. To enhance the competitiveness of Jordanian enterprises, companies embrace a series of proven techniques; one of them is lean production (LP) that consolidates work tasks with minimum waste resulting in greatly reduced wait time, queue time, and other delays. It involves identifying and eliminating non-value adding activities in design, production, supply chain management and customer relations.

1.1 Lean Production philosophy

In its most common form, lean production is a synonym for the Toyota Production System (TPS). Lean production, as a concept, has two driving forces: to continuously eliminate the source of waste, and to continuously add value. LP is the elimination of anything not absolutely required to deliver a quality product or service, on time, to our customers. Defining lean production requires first examining its historical evolution and identifying the different perspectives that are commonly invoked in describing it (Shah and Ward, 2007) as shown in Figure 1.

Lean production is doing your work in the least wasteful way possible. That's the heart of LP. The "Soul" of lean production is getting everyone involved in the continuous improvement process so they treat the company, suppliers and customers like they own the place (Hanover, 2011). LP is doing more with less inventory, fewer workers, less space.

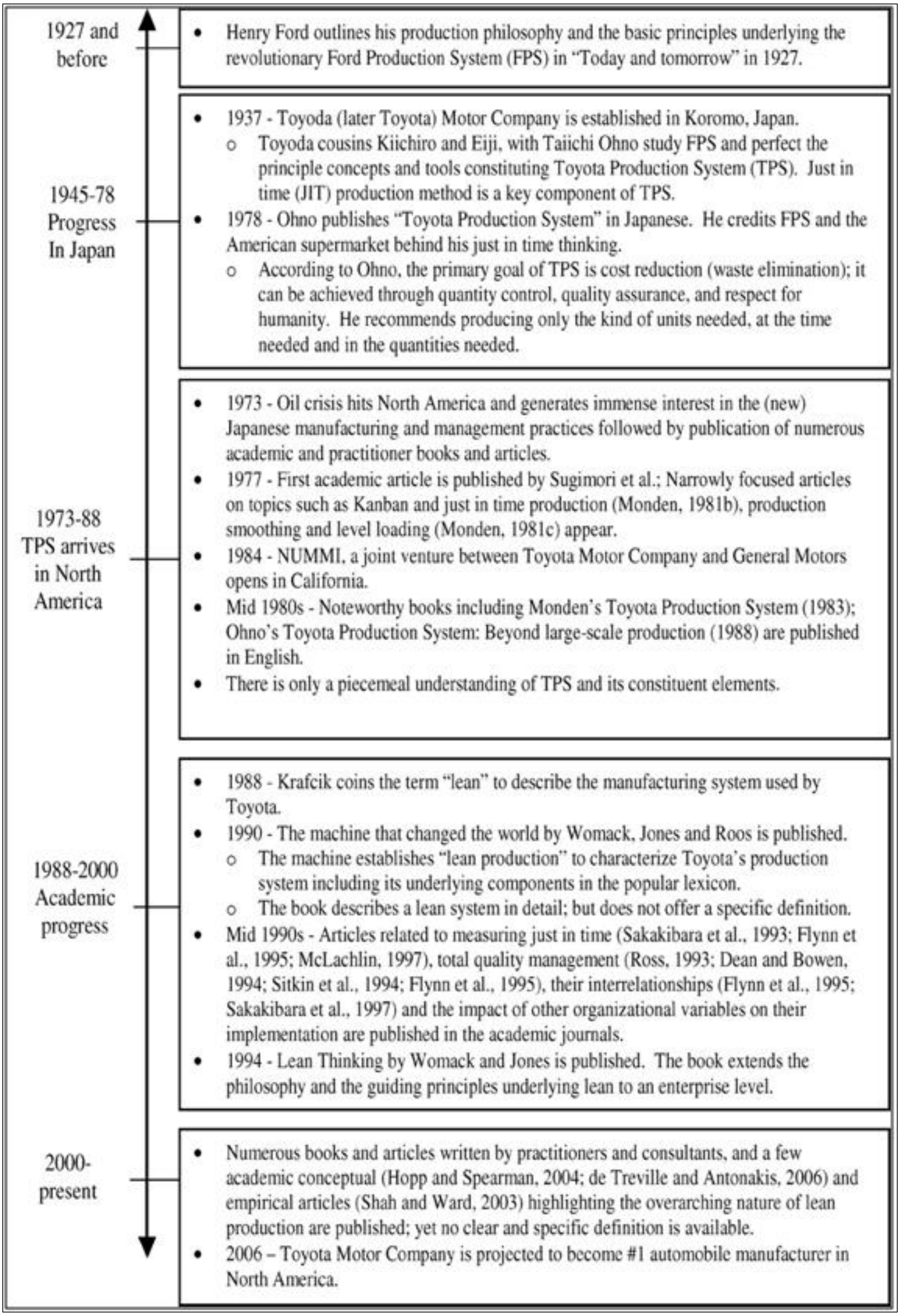

Figure 1 Time line marking the critical phases in the lean production evolution (Shah and Ward, 2007)

LP combines the advantages of craft and mass production, while avoiding the high cost of the former and the rigidity of the latter. Toward this end, lean producers employ teams of multi skilled workers at all levels of the organization.

In addition, LP changes how people work but not always in the ways we think. Most people (employees) will find their jobs more challenging as lean production spreads. And they will certainly become more productive. At the same time, they may find their work more stressful, because a key objective of LP is to push responsibility far down the organizational ladder. Responsibility means freedom to control one’s work – a big plus – but it also raises anxiety about making costly mistakes. Clearly, the skills and knowledge embodied in the workforce are a critical, if not the most critical, element of lean production (Shah and Ward, 2007).

LP as a philosophy is to shorten lead times and reduce costs by redirecting waste and improving employee performance, skills and satisfaction (Bayou, 2008). LP is the use less of everything compared with mass production—half the human effort in factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products (Harrison, 1998).

The benefits of lean production (Melton, 2005) seen within industries are well documented; these benefits include:

- improved quality;
- lower costs;
- reduced space requirements;
- shorter lead time;
- increased productivity;

- decreased lead times for customers;
- reduced inventories for manufacturers;
- improved knowledge management;
- more robust processes (as measured by less errors and therefore less rework).

1.2 Types of Waste

As previously discussed, waste source elimination, defined as the elimination of non-value added and not necessary processes and inventories, is a main focus of lean production. These non-value adding activities or processes can be structured into the following types of waste (Liker, 2004):

1. **Overproduction.** Producing items for which there are no orders. This leads to overstaffing and storage and transportation costs.
2. **Waiting (time on hand).** Workers merely serving to watch an automated machine or having to stand around waiting for the next processing step, tool, supply, part, etc., or having no work because of stock outs, lot processing delays, equipment downtime, and capacity bottlenecks.
3. **Unnecessary transport or conveyance.** Carrying work in process (WIP) long distances, creating inefficient transport, or moving materials, parts, or finished goods into or out of storage or between processes.
4. **Over processing or incorrect processing.** Inefficient processing due to poor tool and product design; causing unnecessary motion and producing defects. Waste is also generated when providing higher-quality products than is necessary.
5. **Excess inventory.** Excess inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long set up times.

6. Unnecessary movement. Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking parts, tools, etc. Walking is also a waste.

7. Defects. Production of defective parts or correction, Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort.

8. Unused employee creativity. Losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to employees.

1.3 Objectives of Lean Production

LP is a set of tools and methodologies that aims for the continuous elimination of the source of all waste in the production process. The main benefits of this are lower production costs; increased output and shorter production lead times. More specifically, some of the goals include (Mekong Capital's, 2004):

1. **Defects and wastage** – Reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, costs associated with reprocessing defective items, and unnecessary product characteristics which are not required by customers;
2. **Cycle Times** – Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times;
3. **Inventory levels** – Minimize inventory levels at all stages of production, particularly works-in-progress between production stages. Lower inventories also mean lower working capital requirements;

4. **Labor productivity** – Improve labor productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible (including not doing unnecessary tasks or unnecessary motions);
5. **Utilization of equipment and space** – Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though existing equipment, while minimizing machine downtime;
6. **Flexibility** – Have the ability to produce a more flexible range of products with minimum changeover costs and changeover time.
7. **Output** – Insofar as reduced cycle times, increased labor productivity and elimination of bottlenecks and machine downtime can be achieved, companies can generally significantly increased output from their existing facilities.

1.4 Key Principles of Lean Production

Key principles behind LP can be summarized as follows (Mekong Capital's, 2004):

- **Recognition of waste**

The first step is to recognize what does and does not create value from the customer's perspective. Any material, process or feature which is not required for creating value from the customer's perspective is waste and should be eliminated. For example, transporting materials between workstations is waste because it can potentially be eliminated.

- **Standard processes**

Lean Production requires an implementation of very detailed production guidelines, called standard work, which clearly state the content, sequence, timing and outcome of all actions by workers. This eliminates variation in the way that workers perform their tasks.

- **Continuous flow**

LP usually aims for the implementation of a continuous production flow free of bottlenecks, interruption, detours, backflows or waiting. When this is successfully implemented, the production cycle time can be reduced by as much as 90%.

- **Pull-production**

It aims to produce only what is needed, how much needed and when it is needed. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation.

- **Quality at the Source**

LP aims for defects to be eliminated at the source and for quality inspection to be done by the workers as part of the in-line production process.

- **Continuous improvement**

Lean Production requires striving for perfection by continually removing layers of waste as they are uncovered. This in turn requires a high level of worker involvement in the continuous improvement process.

1.5 Lean production practices

Organizations of all sizes are trying to stay competitive and profitable for a long-term period. Studies focused on linking lean production practices with organizational performance. One way of grouping the characteristics of lean production practices (Pettersen, 2009) is presented in Table 1.

Table 1 A suggestion for a grouping of lean production characteristics (Pettersen, 2009)

Collective term	Specific characteristics
Just in Time practices	Production leveling (heijunka) Pull system (kanban) Takted production Process synchronization
Resource reduction	Small lot production Waste elimination Setup time reduction Lead time reduction Inventory reduction
Human relations management	Team organization Cross training Employee involvement
Improvement strategies	Improvement circles Continuous improvement (kaizen) Root cause analysis (5 why)
Defects control	Autonomation (jidoka) Failure prevention (poka yoke) 100% inspection Line stop (Andon)
Supply chain management	Value stream mapping/flowcharting Supplier involvement
Standardization	Housekeeping (5S) Standardized work Visual control and management
Scientific management	Policy deployment (hoshin kanri) Time/Work studies Multi manning Work force reduction Layout adjustments Cellular manufacturing
Bundled techniques	Statistical quality control (SQC) TPM/preventive maintenance

Another structure for grouping the lean production practices by mapping them into various impact areas. One of these impact areas is Manufacturing Equipment and Technology (MET). This thesis will focus on MET production. As shown in Table 2,

LP practices in MET production area can be classified into: specific equipment configurations (group technology, cellular layouts, and continuous flow), total preventive maintenance, visual control, new equipment/technologies, and production process reengineering and shared vision of perfection. More details about these lean practices are illustrated in the following section.

Table 2 Six lean production practices related to MET

Impact Area	Lean Production Practice
Manufacturing equipment and technology (MET)	1. Specific equipment configurations (group technology, cellular layouts, continuous flow) 2. Total preventive maintenance 3. Visual control 4. New equipment/technologies 5. Production process reengineering 6. Shared vision of perfection

1.6 Manufacturing equipment and technology

Manufacturing equipment and technology (MET) includes various types of machine tools required to manufacture finished products which range from simple hand-held tools, to highly complicated machines and so forth. Of course it also involves several different lean production practices which can be a subject matter of different detail discussion (Ricky, 2009). Following section include details about each lean production practice that can be implemented in MET production:

1.6.1 Specific equipment configurations (group technology, cellular layouts, and continuous flow)

Specific equipment configurations are unique identification, controlled storage, change control, and status reporting of selected intermediate work products, product

components, and products during the life of a system. It is the process of identifying and defining the items in the system, controlling the change of these items throughout their lifecycle, recording and reporting the status of items and change requests, and verifying the completeness and correctness of items (Norin and Karlström 2006).

Since specific equipment configurations are a supporting discipline and not actually primarily involved in creating any executable code, the whole discipline could by lean principles be considered as waste. However a total lack of specific equipment configurations would lead to a chaotic situation without any progress at all in most projects, so the difficulty lies in identifying just enough specific equipment configurations to be effective without waste (Norin and Karlström 2006).

Group Technology (GT) is a processing philosophy based on the principle that similar products should be processed similarly. GT is a technique for identifying and bringing together related or similar components in a production process in order to take advantage of their similarities to gain the inherent economies of flow line production. However, the scope and scale of implementation will vary with the variety of components being made, the volumes of production, the stability of demand, and most importantly, the production processes required to make them. In the following, some of the principles of GT are addressed (Shahin and Janatyan, 2010).

- Constitute groups of products (part family) and GT cells

Groups of product are the number of products that have the similar design characteristics or similar manufacturing processes. Grouping the products is an important step in the use of this technique.

- Design conformance

One of the important and practicable benefits of GT based on proper coding system and classification is refining design information and design justification. Design

conformance helps to standardize process plan; group scheduling; group tooling setup; and improve inventory purchasing requirements.

Constituting groups of products and GT cells according to similar characteristics of design such as shape, dimension, material and process of production, classifying and coding provides the basis for identifying the products rapidly in systems and this grouping reduces the time of preparing, storing, lead time and empowers the operation process to decrease over production. Reduction of over production in turn influences waste in lean production and enhances productivity (Shahin and Janatyan, 2010).

Cellular manufacturing is a successful application of group technology (GT) concepts. The aim of a cellular manufacturing system is to identify similar manufacturing processes and features where machines are grouped into machine cells based on their contributions to the production process (Mahdavi et al. 2008).

Cellular manufacturing has received considerable interest owing to its promising application as an appropriate manufacturing philosophy for lean production. Cellular layout, i.e. the grouping of parts with similar design features or processing requirements into part families and the corresponding machines into machine cells, is the first stage of designing an effective system (Tsai and Lee 2006). The important step in the design of a cellular layouts is to identify the part families and machine groups and consequently to form manufacturing cells. The cellular layouts are found very effective, efficient and practical (Hachicha et al. 2008).

Continuous flow is the ultimate objective of lean production (Rother and Harris 2001). A cell is an arrangement of people, machines, materials, and methods with the processing steps placed right next to each other in sequential order, through which parts are processed in a continuous flow (or in some cases in a consistent, small batch size that is maintained through the sequence of processing steps).

1.6.2 Total preventive maintenance

Preventive maintenance (PM) is defined as a system of daily maintenance, periodic inspection, and preventive repairs designed to reduce the probability of machine breakdown (Russell and Taylor, 2001). Preventive maintenance plays an important role in operations management with benefits ranging from cost reductions and decreased downtime, to safety and improved performance. The primary reasons for preventive maintenance are to reduce unexpected downtime and repair costs caused by machine breakdown. When maintenance is delayed, one risks losing the true value of the capital, premature equipment failure, and product damage and production delays (Hardman, 2002).

Essential care is a compilation of processes that will prevent failures from occurring. For example lubrication, alignment, balancing, cleaning, and operating procedures, adjustments and installation procedures. Essential care prevents failures (prolong life of equipment). Fixed time maintenance is sometimes selected for equipment with a known life. The equipment is replaced periodically on a fixed time interval.

Fixed time maintenance prevents failures from occurring (without prolonging life). Objective condition monitoring is preferred over subjective condition. Objective methods are for example vibration analysis, ultrasonic, and temperature-, pressure-, voltage- and ampere readings. Subjective inspections are look, listen, feel and smell. Preventive maintenance is essential care and fixed time maintenance together. Both essential care and fixed time maintenance prevents (both prevent) failures, while conditions monitoring only detects failures early (Idhammar, 2009).

PM reduces the amount of reactive maintenance to a level that allows other practices in the maintenance process to be cost effective (Eti et al. 2006). In lean

production organizations, the maintenance function assumes greater responsibility and has greater visibility. The LP enterprise relies much more heavily on the operator for many of the maintenance tasks, especially simple preventive maintenance (Meredith and Shafer, 2007).

Preventive maintenance is a system of periodic inspection and maintenance to keep machines operating. Under-maintaining assets leave an evident waste trail as it often results in frequent and long breakdowns, high levels of unplanned work and lost production and output. Under-maintaining is a regular target of continuous improvement programs (Anderson, 2002).

Workers carry out regular equipment maintenance to detect any anomalies. The focus is changed from fixing breakdowns to preventing them. Since operators are the closest to the machines, they are included in maintenance and monitoring activities in order to prevent and provide warning of malfunctions (Feld, 2000).

In lean production it is imperative to prevent maintenance needs and to perform the remaining maintenance more effectively. If the previous concepts are implemented, then the production reliability will increase and thus the production costs, including maintenance costs and costs for storage, will decrease (Idhammar, 2008).

1.6.3 Visual control

Visual control (VC) is any communication device used in the work environment that tells us at a glance how work should be done and whether it is deviating from the standard. It helps employees who want to do a good job see immediately how they are doing. It might show where items belong, how many items belong there, what the standard procedure is for doing something, the status of work in process, and many other types of information critical to the flow of work activities. In the broadest sense,

visual control refers to the design of just-in-time information of all types to ensure fast and proper execution of operations and processes (Liker, 2004).

It is a process to help increase efficiency and effectiveness by making things visible. Several companies use visual control to make things easier or more effective by the use of visual signals. VC is designed to manage or control the operations (processes) so as to meet the following purposes (Chu, 1996):

- make the problems, abnormalities, or deviation from standards visible to everyone and thus corrective action can be taken immediately,
- display the operating or progress status in an easy to see format.
- provide instruction.
- convey information.
- provide immediate feedback to people.

Therefore VC is the principle of increasing efficiency and effectiveness simply by deliberately making things visible. When things are visible, they are kept in conscious mind. It also serves to ensure that everyone has a common viewpoint of what is being displayed.

Visual controls have been developed by lean production as communication aids and are used to help drive operations and processes in real time (Parry and Turner 2006). Implementing VC in the plant would help companies to exposing abnormalities, problems, deviations, waste, unevenness, and unreasonability to people, thus corrective actions can be taken immediately to:

- correct the problems
- reduce manufacturing costs and possible waste
- shorten production lead time and thus keep the delivery due date

- reduce inventory
- ensure a safe and comfortable working environment
- increase company's profit

1.6.4 New equipment/ technologies

Corporations increasingly rely on technology to establish competitive postures in the global marketplace. As corporations expand into new markets, their success is in part determined by the ability to transfer competitive technologies to local subsidiaries.

A good technology transfer can enable a company to improve productivity, efficiency and adaptability, international expansion, and sustainable competitive advantage. Technology is embodied in every value activity of a company and is involved in achieving linkages of the activities. By improving efficiency of these activities, technology helps to reduce production cost and increase productivity (Gisselquist and Grether, 2000).

Technology also contributes to the quality and uniqueness of products, which enhances product differentiation and increases market demand and sales. At the same time, technology is closely related to the supporting management activities in a company.

For example, information technology improves the efficiency of information processing in an organization, which supports management decision-making and strategy implementation. Cost reduction and increased product demand directly contribute to company's' financial performance; improved management activities enhance the implementation of effective competition strategies and contribute indirectly to company performance (Shaojie et al .2006).

Technology is knowledge of systematization, and it is about design, production method or management system involved hardware or software. Briefly speaking, technology focuses on the know-how towards a specific technique and method to solve a problem. Technology has been evolved by science research and it is a critical element for economic development of industry (Gisselquist and Grether, 2000).

With the rapid advancement of technology, product life cycle is shortening continuously. In order to compete against other companies in competitive global markets, a company has to keep developing new technology to differentiate itself from others. The acquisition of new core technology equipment is especially important for manufacturing advanced products, and the technology know-how of the equipment must be transferred completely from equipment supplier to engineers and operators of the firm to effectively utilize the equipment (Lee et al. 2010).

The use of new technology will lead to; less maintenance required; better maintainability and smart tools and methods and so better lean production implementation (Idhammar, 2008).

1.6.5 Production process reengineering

The traditional management concepts for organizing and the division of labor are considered to be no longer applicable in a world of global markets, changing customer requirements and rapid communication. The recipe of change, commonly known as reengineering is based on the same primary assumption: Organizations will have to refocus on their basic task, satisfying customer needs. Even though the means for achieving change differ between the approaches, they share a commonality: A focus on processes instead of functions.

Production process reengineering also known as business process reengineering (BPR) is defined as a radical redesign of processes in order to gain significant improvements in cost, quality, and service. Companies have been reengineering various business functions for years, ranging from customer relationship management to order fulfillment, and from assembly lines to logistics.

Reengineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, and service and speed (Hammer and Champy 1993). A business process (Mayer et al., 1998) is a series of steps designed to produce a product or a service. It includes all the activities that deliver particular results for a given customer (external or internal). Business process reengineering is one approach for redesigning the way work is done to better support the organization's mission and reduce costs. Reengineering starts with a high-level assessment of the organization's mission, strategic goals, and customer needs.

1.6.6 Shared vision of perfection

A basic lean production principle is to seek perfection; it would suggest there is no end to an organization's lean journey. Leadership strategies that target perfection, focus on means, and sustain commitment maximally position individuals and businesses to become excellent (Braggs and Lesniak, 2010). Perfection begins in small ways by doing excellent work. Perfection consists not in doing extraordinary things, but in doing ordinary things extraordinarily well (Arnauld, 2011).

The lean production principles begin with a systemic evaluation of waste throughout the entire product value chain, actively engage employees on an on-going basis, depend on and reflect close coordination with customers and suppliers, and

develop, track, and publicly display performance metrics. Importantly, these principles are also embedded in a continual improvement system that reflects a commitment to "pursue perfection" and the belief that improvements and change is never complete (Ross, 2000).

1.7 Literature review

Reviewing the existing literature provides a starting point in defining lean production practices. Most companies have a major opportunity to reduce waste through the application of lean production principles. A number of tools have been developed to help organizational leaders assess their progress toward becoming a LP enterprise. Among the huge set of lean production tools, most of them were created to solve specific problems, such as high work in-process level, low availability of equipment, or long setup time.

1.7.1 Lean production review

Lean production developed from the massively successful Toyota Production System, focusing on the removal of all forms of waste from a system (some of which are difficult to see). Bayou et al. (2008) defined leanness as a dynamic, relative and long-term concept. Accordingly, they have developed a relative measure of lean production, which has the following characteristics: relative, dynamic, long-term fuzzy logical, objective, integrative and comprehensive. Manufacturing leanness formulates leanness as (1) a fuzzy concept because leanness is a matter of degree, e.g., a firm can become slightly lean, moderately lean or highly lean, (2) relative across time for the same entity, (3) relative across firms in an industry, (4) integrative of the multitude of different practices used to achieve leanness, (5) comprehensive by associating resources used in production to the organization goals, (6) long-term for studying the lean effect over a

number of years and (7) objective since it uses audited data. The leanness measure (LM) utilizes the fuzzy-logic methodology since lean production is a matter of degree.

In the past several decades, pioneers of lean production have developed numerous useful tools and techniques to realize the waste-elimination concept (Wan and Chen, 2009). Only a few of them support lean production practitioners on identifying the problematic areas to be improved. However, choosing the right Lean Production tools to apply at the right time on the right spot often requires extensive knowledge and experiences of Lean Production implementation; while this kind of expertise is not always accessible or affordable (Wan and Chen, 2009).

1.7.2 Lean production assessment tool review

A large amount of tools and techniques have been developed that allow engineers to follow various problems, eliminate source of wastes, and become lean production. Among the huge set of LP tools, most of them were created to solve specific problems, such as high work in-process level, low availability of equipment, or long setup time etc.

Selecting the right tools for their current condition becomes the key to success in lean production implementation. Extensive knowledge and experiences are needed for identifying the correct tools. Practitioners need to learn ‘‘where to start’’ and ‘‘how to proceed’’ in addition to know the available tools.

Sánchez and Pérez (2001) developed an integrated check list of 36 lean production indicators to assess manufacturing changes towards lean production. The indicators are based on the work of Karlsson and Åhlstöm (1996). The indicators are classified into six groups: multifunctional teams, elimination of zero-value activities,

production and delivery JIT, continuous improvement, supplier integration, and flexible information system.

Goodson (2002) developed the Rapid Plant Assessment (RPA) concentrates on the assessment of the production environment. At the core of the RPA process are two tools for the teams performing plant tours. The RPA rating sheet has 11 categories for assessing the Leanness of the plant. The RPA questionnaire provides 20 associated yes-or-no questions to determine if the plant uses practices in the previous categories. A more detailed list of rating considerations is available at the RPA website.

Nightingale and Mize (2002) investigated the lean production Enterprise Self Assessment Tool (LESAT) which focuses on assessing the degree of a company’s maturity in its use of lean production principles and practices. The LESAT was designed for use in the assessment of the company’s current and future states by its management and for continual improvement in the company’s capability to meet its lean production vision.

The LESAT assesses both the organization’s leanness and its readiness to change. It is constructed of 54 lean production practices. Those practices are not meant to be all-inclusive, but they should serve some of the more important behaviors that a Lean Production organization should have. The selected lean production practices are presented in the form of matrices. Each matrix has five maturity statements ranging from least capable to world-class.

Soriano-Meier and Forrester (2002) developed an instrument for assessing both the degree of the adoption of lean production principles and the degree of commitment to lean production in manufacturing companies. Their method is based on the definition of leanness from Karlsson and Åhlström (1996) and Boyer (1996).

Soriano-Meier and Forrester (2002) suggested that two questionnaires can be deployed in an adapted format for data collection to test the leanness of manufacturing companies. The first questionnaire assesses the adoption of lean production practices. The questionnaire assesses nine leanness variables, which focus on technical lean production practices such as elimination of waste. The second questionnaire assesses the managerial commitment to lean production.

The total commitment is measured by assessing the commitment to both JIT and Total Quality Management (TQM) programs in terms of quality leadership, group problem solving, training, and worker empowerment.

The development of a survey instrument to assess the implementation of lean production practices within an organization was described by Doolen et al. (2005). Results of a literature review, which was used to identify lean production manufacturing practices and existing lean production assessment tools, are presented.

The findings of this review were synthesized to develop an instrument to assess both the number and the level of implementation of a broad range of lean production practices in an organization. The survey did provide a mechanism for comparing the lean production implementation strategies of different organizations within this industrial sector. By comparing both the variety and extent of lean production practices being implemented, this study has demonstrated that it is possible to empirically evaluate the applicability of lean production practices to different manufacturing organizations.

Srinivasaraghavan and Allada (2006) proposed a method that quantifies a company’s production leanness and advises improvement areas. The method is a complementary model that assists contemporary lean production assessment methods. It

provides a quantitative measure of leanness by benchmarking the focal company against lean production companies. A survey was designed based on the LESAT and Lean production characteristics to collect input data for the method. The results for different improvement scenarios are presented in terms of money. Each scenario gives a target value for each parameter included in the assessment. They suggested that the method could be used to measure improvement in any specific area of an organization.

A case where lean production principles were adapted for the process sector for application at a large integrated steel mill was described by Abdulmalek et al. (2006). Value stream mapping was the main tool used to identify the opportunities for various lean production techniques. The study described a simulation model that was developed to contrast the ‘‘before’’ and ‘‘after’’ scenarios in detail, in order to illustrate to managers potential benefits such as reduced production lead-time and lower work-in-process inventory.

Sustainable lean production requires attention to both performance improvement and capability development as suggested by Jorgensen et al. (2007). A framework for describing levels of lean production capability is presented, based on a brief review of the literature and experiences from 12 Danish companies currently implementing lean production. Although still in its emerging phase, the framework contributes to both theory and practice by describing developmental stages that support lean production capability development and consequently, lean production sustainability.

Shah and Ward (2007) suggested that lean production may be viewed as a configuration of practices, specifically, an integrated system composed of highly interrelated elements. In their study developed a framework, which identifies the ten most salient dimensions of lean production. The dimensions consist of 48 practices and

tools, which are evaluated based on how extensive their implementations are. Their framework can be used to assess lean production implementations in companies by using a survey questionnaire, which was developed in their study.

Bayou and de Korvin (2008) developed a systematic and relative measure of leanness, which can be used to compare companies' production systems with each other and across time.

The proposed fuzzy-logic method sees leanness both as a matter of degree and as an integrative set of practices used to achieve leanness. The measure is also long term because it can be used to study the lean production effect over the years. The fuzzy-logic leanness measure (fuzzy-logic LM) includes three lean production practices: JIT, Kaizen and TQM.

Wan and Chen (2008) categorized lean production assessments into value stream mapping techniques, lean production assessment tools, lean production metrics, and benchmarking processes. Typical lean production assessment tools have questionnaires, which survey the extent of the adoption of lean production principles. Lean production metrics are performance measures for monitoring the effectiveness of improvement efforts.

Wan and Chen (2008) developed a data envelopment analysis leanness measure (DEALM), which quantifies the leanness level of a manufacturing system based on a benchmark of ideal leanness obtained from historical data. The measure can also be weighted to align with the company's strategic focus. The leanness level is presented as a single score. The three dimensions of the DEALM are time, cost, and value. The measure identifies the value and non-value added processes, and focuses on eliminating the latter.

1.8 Problem definition

Organizations of all sizes are trying to stay competitive and profitable for a long-term period. Most companies have a major opportunity to reduce source of waste through the application of lean production principles. Lean production developed a large amount of tools and techniques that allow solving various problems thought the alimentation of source of wastes in various impact areas of production such as; Manufacturing Equipment and Technology (MET), processes technology and know-how, product design and development etc.

Implementation of lean production principles in such impact areas of production provides a potential solution to improve the competitiveness of industries, therefore a development of an assessmnet tool for the implementation of such lean principles can be an effective way to guide the lean implementation process in the Jordanian industries. A need for such assessmnet tool arises to improve company's efficiency. The implementation of the right tool at the right time on the right impact area of production relies on extensive knowledge and experiences. However, expert's interviews and literature review is an essential steps to acquire knowledge exists about the current state of lean production implementation within Jordanian industries.

1.9 Research objectives

The main goal of this study is to develop an assessmnet tool for the implementation of lean production principles in the Jordanian industries that provides an effective way to guide lean implementation. An assessment tool is generated adaptively for each user to evaluate the current status of the system, pinpoint the urgent targets for improvement, and identify the appropriate tools and techniques for developing action plans. This assessment tool links the knowledge and expertise of lean production with practical

actions, so that the lean production concepts can be implemented more systematically and efficiently.

This thesis concentrated in lean productions practices in MET impact area. In particular, this research aims to empirically evaluate the level of awareness, the implementation status, and the need for assessment tool in implementing lean production principles related to MET within the Jordanian industries by means of a questionnaire survey.

By investigating the benefits of lean production in the companies and develop an evaluation tool to prove or disprove that the companies have gained from MET implementation. In order to achieve the fore mentioned objectives, a data collection method must be selected. Questionnaire is selected as a data collection method, since it is feasible and available way to be used in this type of research. Then hypotheses were tested, a structural model was developed and findings were reported.

Although, companies have introduced various tools to improve their quality profile and decrease waste, yet there is a need to continually assess the practices of LP. In this context, based on the previously mentioned literature, this research will be conducted in Jordan industries to determine the important factors that have significant effects on MET lean production implementation. The methodology to achieve this purpose is introduced in the following chapter.

Chapter Two
RESEARCH METHODOLOGY

In this research methodology is described, the selected sample is presented, procedures used in designing a proper data collection method is explained, consequently the conceptual frame work with the corresponding hypotheses is introduced. A questionnaire with its measurements, pilot study, and lean production survey is constructed. Finally, a suggested model is developed and a lean production assessment tool for it is conducted.

2.1 Conceptual framework

Based on a comprehensive literature review, a comprehensive set of practices considered to be essential in a lean production enterprise and to identify existing survey instruments that could be used to complete a broad-based assessment of the lean production practices used within an organization (Doolen and Hacker 2005). The diagram shown in Figure 2 captures the conceptual framework for this research.

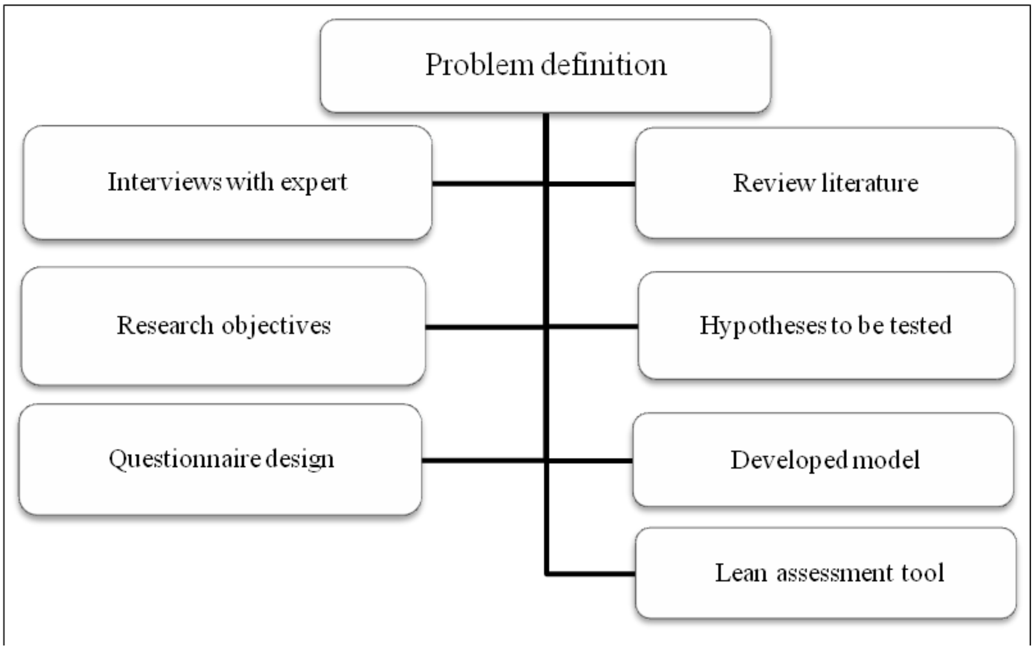

Figure 2 The conceptual framework of this research

2.2 MET practices review

Six lean practices can be implemented in MET production area these are:

1. **Specific equipment configurations (group technology, cellular layouts, and continuous flow)**

Norin and Karlström (2006) related the specific equipment configurations with visual control. Specifically, by making specific equipment configurations support lean production principles we assert that it is possible to reduce the overhead involved in configurations activities, increase the possibility of rapid feedback through more frequent iteration deliveries and to be able to visual control more rapid change. The results of these effects should ultimately lead to increased return on investment (ROI) for the firm. As such, we theorize:

$H1_1$: Specific equipment configurations are positively related to visual control.

Shahin and Janatyan (2010) discussed how group technology reduces the time of preparing, storing, lead time and empowers the production process reengineering to decrease over production. Reduction of over production in turn influences waste in lean production and enhances productivity. Also Tsai and Lee (2008) explained that cellular layouts, is the first stage of designing an effective system. Hachicha et al. (2008) clarified the important step in the design of cellular layouts to be very effective, efficient and practical. Rother and Harris (2001) discussed the continuous flow and how maintained through the sequence of production process reengineering steps. So, formally stated:

$H1_2$: Specific equipment configurations have a significant, positive effect on production process reengineering.

2. Total preventive maintenance

Competitive pressures on production organizations have obliged them to look at all improvement possibilities. Among the most popular and well documented change interventions has been production process reengineering as Hipkin and Cock (2000) have mentioned. As the management now accounts for a rapidly increasing share of operational costs, greater attention is being directed to maintenance thinking. As such, we theorize:

$H1_3$: Total preventive maintenance has a significant, positive effect on production process reengineering.

Eti et al. (2006) explained that economic and political realities forced managers to reverse longstanding organizational cultures in order to reduce costs and energy expenditures in their organizations. For instance, these can be achieved, with respect to preventive maintenance.

$H1_4$: Total preventive maintenance has a significant, positive effect on shared vision of perfection.

3. Visual control

Swenson (1993) found that visual controls are appropriate to accomplishing tasks that are waiting for them to do; exceptions can be handled in an efficient manner. Studies have shown that automating an existing manual work process will have a very slight effect on productivity. Instead, if the entire process is examined, and then redesigned to take into account capabilities provided by technology, phenomenal increases in productivity can be achieved. These increases in productivity typically arise out of reducing the number of individual steps to complete a process. Therefore, we theorize:

H1$_5$: Visual control has a significant, positive effect on production process reengineering.

While there are many cases when manufacturing equipment and technology can be used to enable visual control, such as display boards connected to sensors or computer terminals and bar code scanners, it is best to develop visual controls from the ground up and only use technology after the visual control method has been thoroughly tested as Gemba (2007) mentioned. While the format on a white board can be changed easily to suit the changing needs of the process, a technology solution may present a time or cost barrier to change. Formally, stated:

H1$_6$: Visual control has a significant, positive effect on manufacturing equipment and technology.

4. New equipment/ technologies

Companies are under constant pressure to be innovative, to introduce new equipment/ technologies and to make process innovations to improve their business performance. Rapid changes in the business environment and global competition forces companies to understand the business opportunities and risks of new technologies, and how important technological innovations are for industrial competitiveness (Li-Hua and Khalil, 2006).

Vehkapera et al. (2009) concluded that, certain functions of new equipment/ technologies were highly appreciated and are mostly related to the engineering activities, such as production process reengineering.

Good new equipment/ technologies can enable a firm to improve production productivity, efficiency and adaptability. New equipment is purchased to acquire new technology, expand capacity and increase competitiveness, so Lee et al. (2010) studied

the effect of new equipment/ technologies and its relation to production process reengineering. More formally stated:

H1$_7$: New equipment/ technologies are positively related to production process reengineering.

Shaojie et al. (2006) explained that new equipment/ technologies contributes to production efficiency and product quality, and therefore helps companies acquire market share. Application of new equipment/ technologies also enables companies to make necessary modifications of the product to adapt to local market demand.

At the same time, new equipment/ technologies improve capabilities of management information processing and increase the efficiency of management activities and their performance and shared vision of perfection. So we can theorize:

H1$_8$: New equipment/ technologies have a significant, positive effect on shared vision of perfection.

5. Production process reengineering

Piirainen et al. (2009) discussed production process reengineering as a popular tool for the management, with the mandate to improve business performance through changing the processes and workflows to a more efficient configuration which enables more output from the same resources in less time.

Chutima and Kaewin (2007) introduced lean and process reengineering model that increase productivity, reduce lead time, continuous improve quality and to pursue perfection. Formally stated:

H1$_9$: Production process reengineering has a significant positive effect on shared vision of perfection.

6. Shared vision of perfection

Braggs and Lesniak (2010) said when shared vision of perfection is targeted; the companies create a culture of excellence by nurturing an environment where individuals commit to sustained personal development as part of their role in the organization. They must place the members of the organization within an inspiring vision in which they see their development as being aligned with an overarching organizational pursuit of perfection.

While Ross (2000) cleared that shared vision of perfection by improves products and processes continuously into the entire lean production taking place throughout the company. These LP principles have resulted in substantial changes in the manufacturing equipment and technology environment and produced significant results. Thus, we theorize:

$H1_{10}$: Shared vision of perfection has a significant, positive effect on manufacturing equipment and technology.

2.3 Hypotheses to be tested

The objective of implementation of lean tools in MET is to achieve significant improvements in companies so that the contemporary customer requirements of quality, speed, innovation, and service are fully satisfied. This can be achieved by adopting a vision and a comprehensive approach to change, focusing on:

1. **Shared vision of perfection:** Leadership and guidance from top management;
2. **Production process reengineering:** Becoming customer focused, understanding why and how processes can be improved, and implementing process benchmarking;

3. **Specific equipment configurations:** Identifying appropriate tools and techniques for redesigning work processes to meet strategic performance goals;
4. **Total preventive maintenance**: Implementing continuous improvement methods to sustain the organizations improved performance.
5. **Visual control:** Applying effective change management to adjust the organizations people and culture to the new ways of working;
6. **New equipment/ technologies:** Implementing information technology to enable improved performance;

Based on the mentioned arguments, the hypotheses (H1(s)) related to the important factors that may affect the overall implementation of MET are proposed. Table 3 summarizes the proposed hypotheses.

Table 3 Summary of proposed hypotheses for MET

Hypothesis		Reference
$H1_1$	Specific equipment configurations are positively related to visual control.	Norin and Karlström (2006)
$H1_2$	Specific equipment configurations have a significant, positive effect on production process reengineering.	Shahin and Janatyan (2010) Tsai and Lee (2008) Hachicha et al. (2008) Rother and Harris (2001)
$H1_3$	Total preventive maintenance has a significant, positive effect on production process reengineering.	Hipkin and Cock (2000)
$H1_4$	Total preventive maintenance has a significant, positive effect on shared vision of perfection.	Eti et al. (2006)
$H1_5$	Visual control has a significant, positive effect on production process reengineering.	Swenson (1993)
$H1_6$	Visual control has a significant, positive effect on manufacturing equipment and technology.	Gemba (2007)
$H1_7$	New equipment/ technologies are positively related to production process reengineering.	Li-Hua and Khalil (2006) Vehkapera et al. (2009) Lee et al. (2010)
$H1_8$	New equipment/ technologies have a significant, positive effect on shared vision of perfection.	Shaojie et al. (2006)
$H1_9$	Production process reengineering has a significant, positive effect on shared vision of perfection.	Piirainen et al. (2009) Chutima and Kaewin (2007)
$H1_{10}$	Shared vision of perfection has a significant, positive effect on manufacturing equipment and technology.	Braggs and Lesniak (2010) While Ross (2000)

2.4 Developed model

The structural developed model shown in Figure 3 illustrates the previously mentioned hypotheses between the different latent of the model.

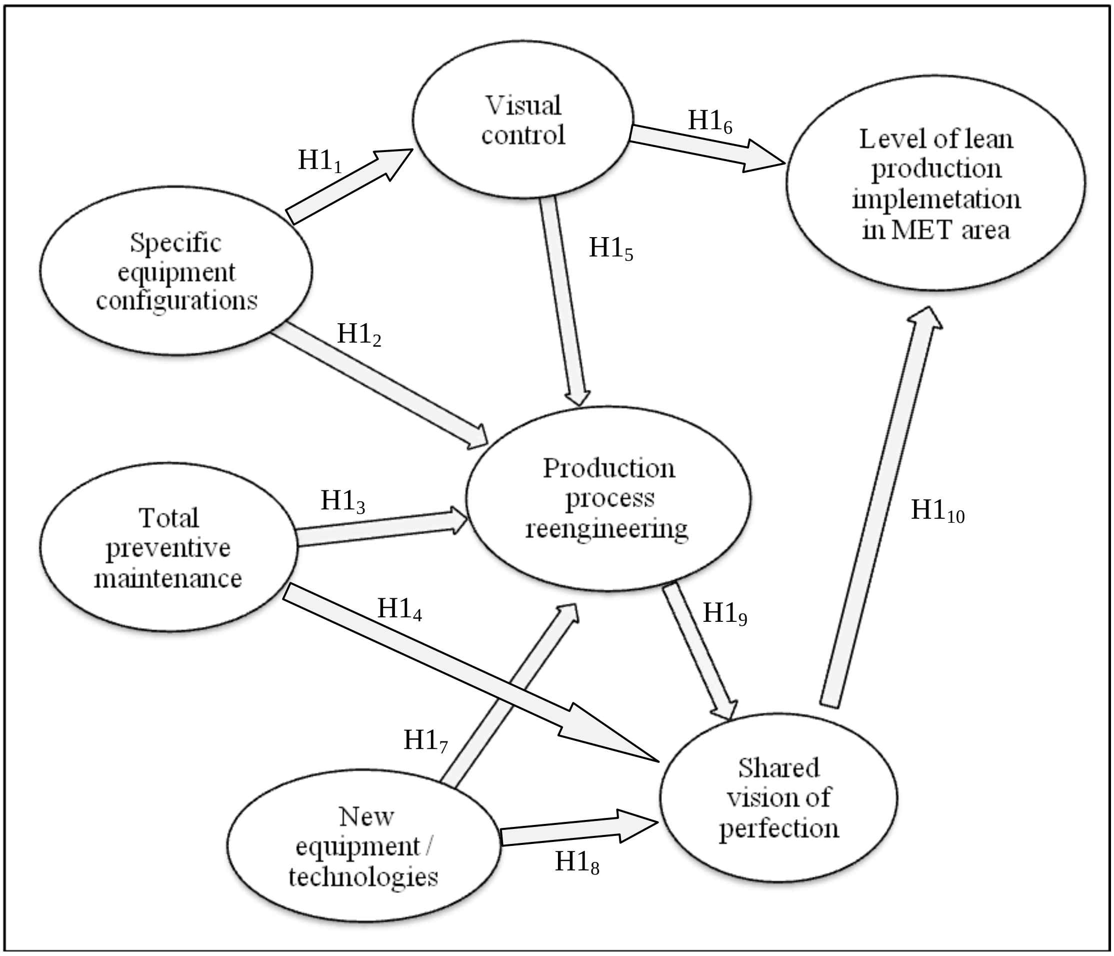

Figure 3 Lean production MET developed model

To test this developed model, data collected by the questionnaire, entered into a spread sheet then uploaded to Statistical Software Package for the social sciences (SPSS 15.0, 2006) for more detailed statistical analysis. Then the model was check and tested by (Amos 16.0.0, 2007) software.

2.5 Questionnaire design

Data collected thought the questionnaire; allow the evaluation of the relations between lean production awareness, implementation status, and the need for developing assessment tool for lean production in the company. To acquire the required information the developed questionnaire was addressed to the Jordanian industries to obtain primary data for this study.

2.5.1 Population and sample size

The population of interest for this study consisted of company operating in the Jordanian industries. Beginning with the original list with 350 companies, 120 were returned that could not be filled. Additionally, questionnaires were also returned (21 questionnaires) because the company was either out of business, or not interested in lean production implementation. End up of 209 companies were surveyed.

2.5.2 Data collection and questionnaire development

The questionnaire was designed to direct respondents to follow-on items, only if the overall practice was used within the organization. The structure chosen for the survey items not only minimized the amount of time to complete the survey, but also provided the respondent with additional details on a particular practice through the follow-on items. Because the follow-on items referenced more specific aspects of the lean production practice in question, this reduced the likelihood that the respondent would misunderstand the overall practice.

The structure also provided a means for determining the practices being implemented, as well as the details of how a particular organization was choosing to

implement the practice. For each item, respondents were asked to evaluate how often a specific lean production practice was used within their organization. A five-point Likert scale (Poor, Fair, Good, Very good, and Excellent) was used. Table 4 shows the key of the questions used in the survey.

Table 4 Key of the survey questions

Scale	Key
Poor	1
Fair	2
Good	3
Very Good	4
Excellent	5

The questionnaire shown in APPENDIX 2 was structured as follows: The first part consisted of three questions to gather basic demographic company information regarding general environment of the enterprise; current position of the person who filled the questionnaire in the enterprise, the type of the organization and industrial sector of the organization.

The second part consists of 39 questions regarding the implementation of the six considered lean practices in MET production area. These questions were designed based on categorical Likert scale that quantifies attitudes on 5 point scale.

To evaluate the level of lean production awareness and lean implementation at a given company, a set of commonly applied lean production elements were identified from previous research (Kirby and Greene 2003, Czabke et al. 2008, Liker 2003) and experience. In Table 2 page 9, the six LP practices related to MET were selected to measure the level of awareness and implementation status of the respondents' organization.

2.5.3 Questionnaire validation, pilot study and data analysis

To validate the questionnaire, it was reviewed by some experts who are working in consultation companies in Jordan; feedback was also obtained from other specialists, details are documented in APPENDIX 3. In addition to that, a pretest pilot study was conducted. A random sample of 25 companies was selected to test the questionnaire for clarity, comprehensiveness, and acceptability as suggested (Rea and Parker, 2005). An electronic mail consisted of a personalized cover letter (APPENDIX 1), and a survey questionnaire (APPENDIX 2) was sent to each of the 25 companies, seven responses were received (28 percent). The responses received were carefully analyzed and changes were made to the questionnaire accordingly as suggested (Rea and Parker 2005).

Responses of participants were collected, coded, and entered into a Microsoft Excel spreadsheet. The data was coded according to categorical Likert scale responses. Then detailed statistical analysis has been carried out.

Frequency distributions, contingency tables, and descriptive statistics were used to summarize high-level analysis of responses (Rea and Parker, 2005). Dimensional data from industry demographics, market structure, and lean production practices were tested. Also the developed model was check and tested by (Amos 16.0.0, 2007) software.

2.6 The developed assessment tool

The developed assessmnet tool reviews the lean production practices and the guiding tools to identify the difficulties and opportunities. The lean production assessment tool is used in conjunction corporate goals for MET and its lean practices to

define the gaps in performance and point out areas of opportunity for "Breakthrough Improvement" that become an integral part of the company plan. Then a lean production assessment chart should be used to monitor progress and effectiveness of the process improvement effort. The current status can be charted along with the target condition goals.

This light and simple lean production assessment is intended to provide a sense of where your company is today on its lean production journey. It is based on six lean production practices. Since this assessment is based on an Excel spreadsheet you will navigate through it through the tabs shown in Figure 4 that include: Introduction- Specific- Maintenance- Visual– Equipment- Reengineering- Perfection- Manufacturing and Assessment Scorecard.

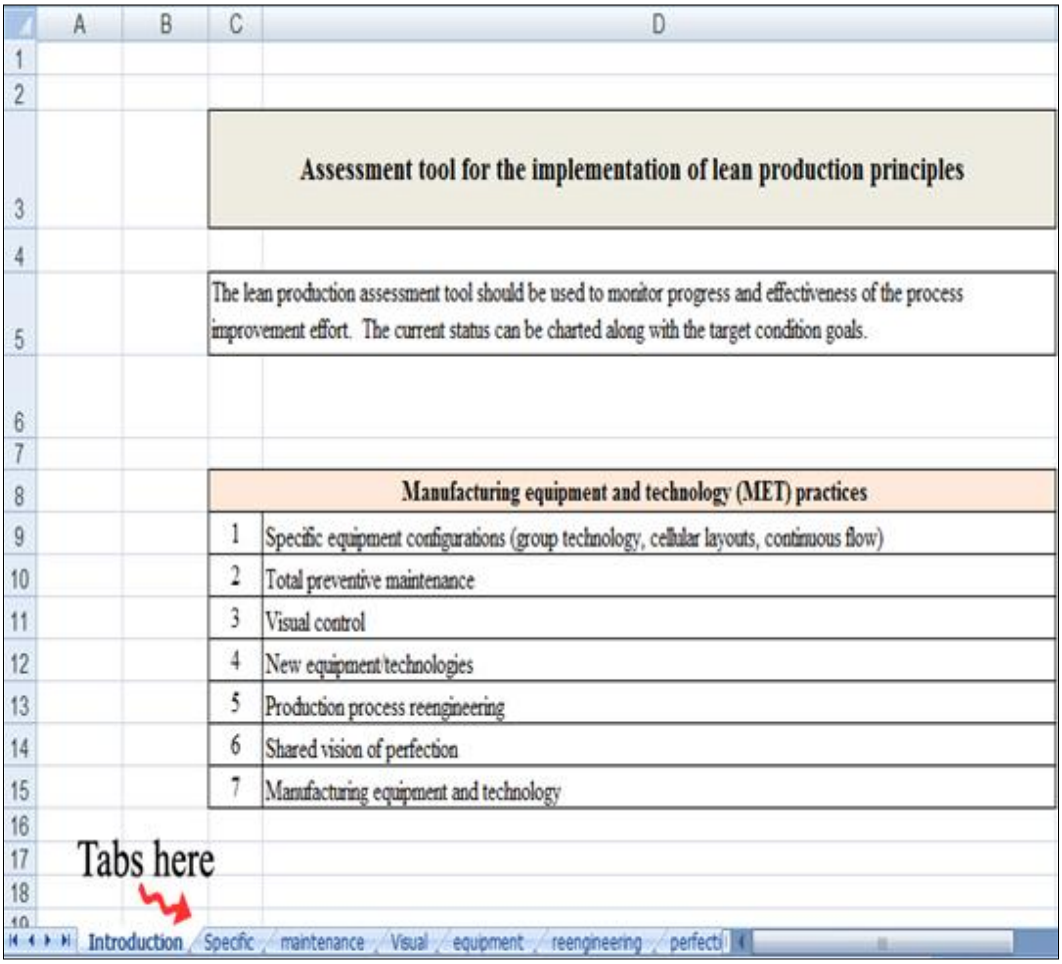

Figure 4 Tabs in the assessmnet tool

Begin by clicking "Introduction" Tab followed by the "Specific" Tab. Simply entering a score of 1 to 5, based on the descriptors provided for each of six common key lean production practices, a composite score is automatically calculated. Once the 6 scores are entered, the assessment provides a scoreboard of what you have achieved. Beside it, the scoreboard is drawn. The assessment enables you to see how your company stacks up against target. And it does this by automatically generating a Spider Graph for quick review as demonstrated by Figure 5.

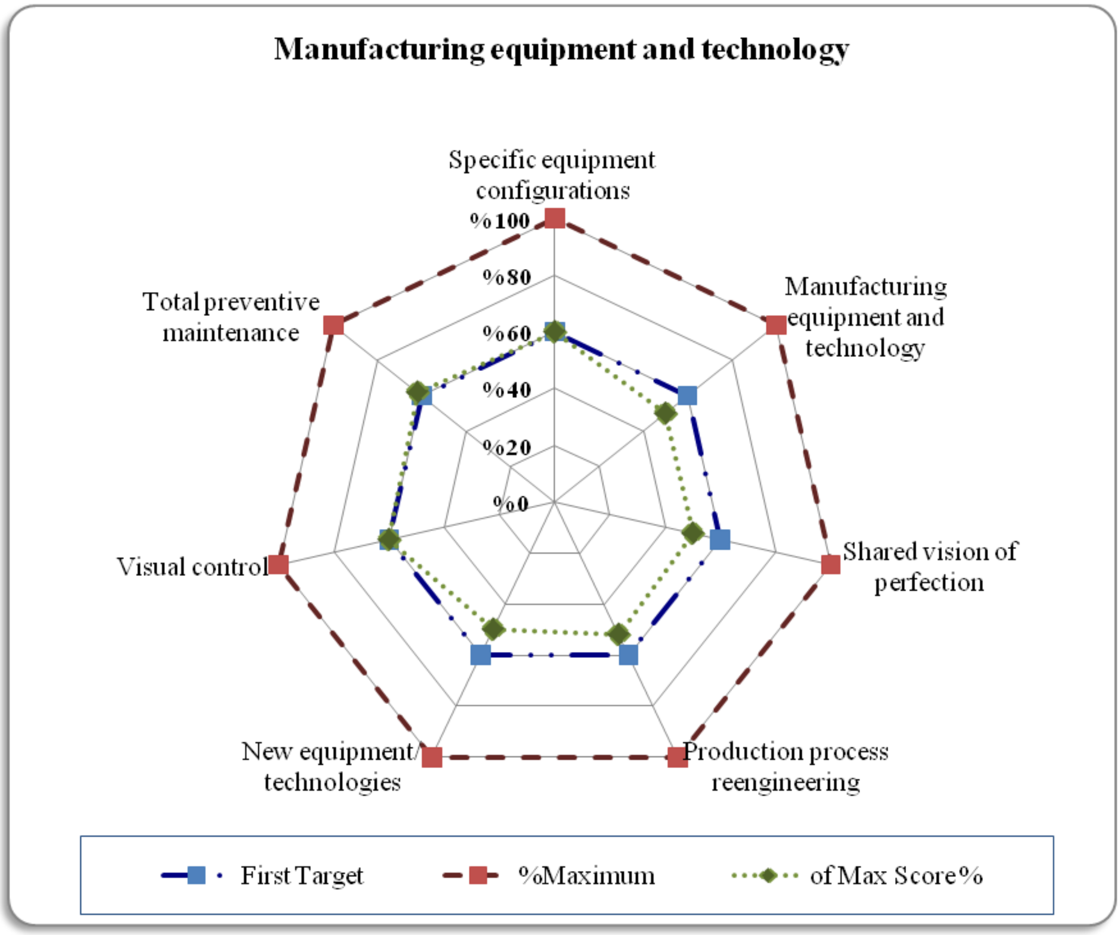

Figure 5 Spider graph for implementation of the six lean tools in MET production area

To get the most from this simple assessment, have all members of company team do it individually first. When done, compare the scores and discuss among yourselves what the collective value should be look at this activity as the rich, joint learning experience it truly is. The last graph will show you where your company is on its lean production journey. While this assessment is an approximation, it is a good start.

Chapter Three
DISCUSSION AND RESULTS

This chapter shows the analysis of demographic profile of the participants and second part of the questionnaire for the developed model. It also includes interpretation of the obtained results, the results from our hypotheses testing and finally the analysis of the developed model.

3.1 Demographic profile of the respondents

The first part consisted of three questions that gather basic demographic company information regarding general environment of the company; current position of the person who filled the questionnaire in the company, the type of the organization and industrial sector of the organization.

Regarding to the type of the organization, 95% of the participated companies were manufacturing facilities and 5% of the participated companies were service companies. Regarding th**e** current position in the enterprise, as shown in Figure 6, 45% of the questionnaires are filled by production manager, 40% filled by quality manager and a few percentage (5%) is filled by general manager.

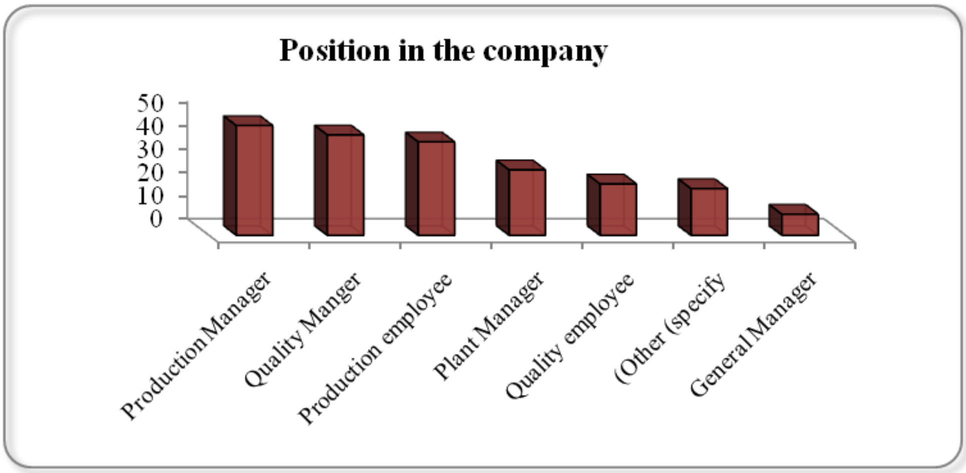

Figure 6 Position of the person who filled the questionnaire in the company

Regarding the specification of industrial sector of the respondent. Figure 7 shows the distribution of respondents into the various industrial sectors.

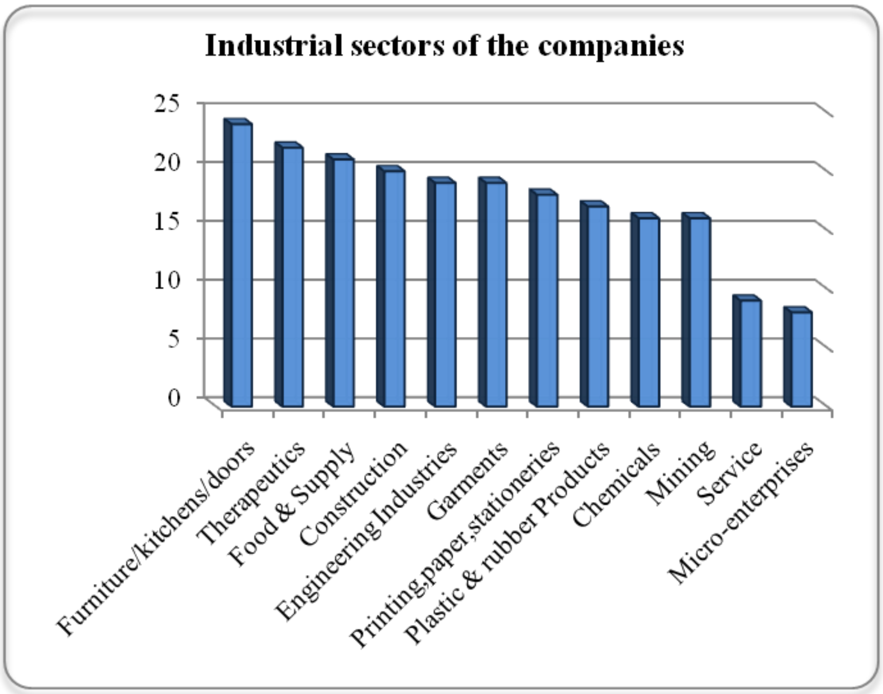

Figure 7 Industrial sectors of the companies who filled this survey

3.2 Interpretation of Results

For each lean production practice under study, the score average for all received responses is calculated then divides by Likert scale here five as show in equation 1 which yields the level of implementation in each lean production practice. Results are to be interpreted as in Table 5.

$$\text{Level of Implementation for LP practice (\%)} = \frac{\text{Score average per LP practice}}{5} \times 100 \quad \ldots 1$$

Table 5 Results interpretation key

Implementation % (I)	I ≤ 20%	20 < I ≤ 40%	40 < I ≤ 60%	60 < I ≤ 80%	80 < I ≤ 100%
Interpretation of implementation level	Poor	Fair	Good	Very Good	Excellent

As an example for the first lean practice entitled "**specific equipment configurations"**. The scores average of every question and the overall score average of this lean practice are represented in Table 6.

Table 6 Specific equipment configurations questions and their averages

Question	Score average
The equipment follows a documented procedure to control changes to configuration items/units.	4.06
Changes in the definition of the product and its specific components are tracked and reported.	3.51
Periodic audits are performed to verify that equipment baselines conform to the documentation that defines them (e.g., by the configuration group).	4.10
Products are classified into groups with similar process requirements.	3.93
Awareness of the variety of specific equipment configurations that can be utilized to improve the production process.	4.00
Work cells have been developed and implemented to support specific product families and equipment configurations.	3.76
Average of lean practice	3.89
Level of implementation for lean practice	**77.89 %**

As shown in Table 6, the level of implementation of lean production practice (Specific equipment configurations) is (77.89 %). The interpretation of implementation level of this lean practice is Very Good.

Summary of results for the other five lean practices related to MET is shown in Table 7. Among lean practices, specific equipment configuration is found to be the leading lean practice, with average score (3.89). Other lean practice that has been extensively implemented is the total preventive maintenance (3.88) and shared vision of perfection (3.87). However, the least practiced lean tools are the new equipment/ technologies and visual control.

Table 7 Summary of results for (manufacturing equipment and technology)

Lean production practice	Average	Level of implementation for lean practice %
Specific equipment configurations	3.89	77.89
Total preventive maintenance	3.88	77.64
Visual control	3.81	76.11
New equipment/ technologies	3.77	75.41
Production process reengineering	3.83	76.61
Shared vision of perfection	3.87	77.49
Overall MET implementation	**3.84**	**76.86**

As shown in Table 7, level of implementation for lean practice % is almost the same for all practices. Most highly implemented lean practice is the specific equipment configuration with implementation level of 77.89 % and the lowest implemented lean tool is the new equipment/ technologies with implementation level of 75.41 %.

3.3 Hypotheses testing results

The *p*-value (probability level) is the probability of obtaining a test statistic that is at least as extreme as the actual calculated value, if the null hypothesis is true. That is, the p-value represents the probability of making a Type I error, or rejecting the null hypothesis when it is actually true. The smaller the *p*-value, the smaller the probability is that you would be making a mistake by rejecting the null hypothesis. For example, if the calculated p-value of a test statistic is less than 0.01, you reject the null hypothesis (Montgomery and Runger 2007).

The ANOVA results for hypothesis testing. $H1_1$ theorized that specific equipment configurations would be positively related to production process reengineering in Jordanian industries. The results support $H1_1$ (p = 0.0, which is less than $p < 0.01$) (Sánchez and Pérez 2001) and performance (Shaojie et al .2006).

However, supportive of $H1_2$, $H1_3$, $H1_4$, $H1_5$, $H1_6$, $H1_7$, $H1_8$, $H1_9$ and $H1_{10}$ were found to be positively related to the overall implementation of lean practices in MET production area.

3.4 Analysis of the developed model

The data collected from the survey was entered into spread sheet and then it was uploaded to the SPSS for more detailed statistical analysis. Then the model fit was check and tested by Amos 16.0.0, 2007 software. The analysis of developed model includes the following statistical analysis tests.

1) Multicollinearity:

Multicollinearity measures the degree by which questions measure the same entity and a probability value of 0.9 or above for the inter-item correlations indicate the possibility that two or more items measure the same entity. The correlation coefficient varies from -1 to 1. Zero correlation means that two things vary separately.

Correlation analysis was conducted between all the questions of each latent of MET. Correlation matrix for the entire MET model is shown in APPENDIX 5. As an example the correlation matrix for specific equipment configurations latent is shown in Table 8.

Table 8 Specific equipment configurations correlation matrix

Question	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
S1	1.00	0.33	0.24	0.12	0.05	0.17
S2	0.33	1.00	0.04	0.25	0.06	0.04
S3	0.24	0.04	1.00	0.39	0.11	0.13
S4	0.12	0.25	0.39	1.00	0.02	0.11
S5	0.05	0.06	0.11	0.02	1.00	0.26
S6	0.17	0.04	0.13	0.11	0.26	1.00

2) Test of Reliability:

When using Likert-type scales it is imperative to calculate and report Cronbach's alpha coefficient for internal consistency reliability for any scales or subscales one may be used. Then the analysis of the data must use these summated scales or subscales and not individual items. If one does otherwise, the reliability of the items is at best probably low and at worst unknown. Cronbach's alpha does not provide reliability estimates for single items (Gliem and Gliem, 2003).

Cronbach's alpha reliability coefficient normally ranges between 0 and 1. However, there is actually no lower limit to the coefficient. The closer Cronbach's alpha coefficient ( ) is to 1.0 the greater the internal consistency of the items in the scale. Based upon the equation 2 (Gliem and Gliem, 2003):

$$CC\ alpha = \frac{r \times k}{[1 + (k - 1) \times r]} \qquad \dots 2$$

Where, is the number of questions considered and is the mean of the inter-item correlations. The size of alpha is determined by both the number of items in the scale and the mean inter-item correlations.

For example, for the entire model, and , and thus for entire model = 0.87. While increasing the value of alpha is partially dependent upon the number of items in the scale, it should be noted that this has diminishing returns. It should also be noted that a Cronbach's alpha coefficient of 0.8 is probably a reasonable goal.

In Table 9 Cronbach's alpha calculated between each latent in the developed model is presented. A value of 0.6 or less for Cronbach's alpha generally indicates unsatisfactory consistency reliability (Gliem and Gliem, 2003).

Table 9 Cronbach's alpha for each latent

Lean production practice (latent)	Cronbach's alpha
Specific equipment configurations	0.78
Total preventive maintenance	0.73
Visual control	0.80
New equipment/ technologies	0.79
Production process reengineering	0.85
Shared vision of perfection	0.83
The overall MET model	**0.87**

Results show that all the model variables have a value of Cronbach's alpha of 0.7 or above and the overall model has a high Cronbach's alpha value of 0.87.

3) Model fitness:

A large class of tests exists for assessing how well the model matches the observed data. A classic goodness-of-fit measure to determine overall model fit is χ^2. A large χ^2 and rejection of the null hypothesis means that model estimates do not sufficiently reproduce sample covariance; the model does not fit the data well. By contrast, a small χ^2 and failure to reject the null hypothesis is a sign of a good model fit.

Another commonly reported statistic is the Root Mean Square Error of Approximation (RMSEA), incorporates a penalty function for poor model parsimony and thus becomes sensitive to the number of parameters estimated and relatively insensitive to sample size. The Amos User's Guide suggests that a value of the RMSEA of about 0.05 or less would indicate a close fit of the model in relation to the degrees of freedom (DF).

Another test used to compare models with respect to model. It is Comparative fit index (CFI) evaluates the fit of a user-specified solution in relation to a more restricted, nested baseline model, in which the covariance's among all input indicators are fixed to zero or no relationship among variables is posited. CFI ranges from CFI ranges from 0 for a poor fit to 1 for a good fit.

In general, if the ratio between the Chi square goodness of fit measure and degrees of freedom is less than 5, there for the model is accepted (Armstrong and Tan, 2000). In this model, the ratio is 3.12 less than 5.0, which is accepted according to the recommended value (Armstrong and Tan, 2000).

Generally in structural equation modeling, the fit of the model using chi-square is not always as straight forward as assessment of the fit of the model, because chi-square value is not independent of sample size. Minimization was achieved for the developed model with a degrees of freedom of (681) and probability level of (p = 0.00) which is less than $p < 0.01$(Sánchez and Pérez 2001), as shown in Table 10. The results are within the acceptable ranges of the recommended values. Convergent validity was assessed by reviewing the *t*-tests for each hypothesis. If all the hypotheses for the relations were greater than twice their standard errors, the parameter estimates demonstrated convergent validity (Lani, 2009). The results showed that all t-tests were effectively measuring the same construct.

Table 10 Results for the hypothesis testing for developed model

Hypothesis	χ^2	DF	*p*-value	RMSEA	CFI	Estimated number	*t*-value	Decision
$H1_1$	240.77	10	0	0.046	0.88	0.55	7.89	Supported
$H1_2$	320.86	10	0	0.044	0.87	0.54	4.95	Supported
$H1_3$	393.45	14	0	0.053	0.92	0.60	6.97	Supported
$H1_4$	351.23	13	0	0.051	0.89	0.36	4.22	Supported
$H1_5$	265.33	9	0	0.041	0.81	0.68	6.99	Supported
$H1_6$	155.41	6	0	0.042	0.79	0.91	11.79	Supported
$H1_7$	357.84	10	0	0.045	0.82	0.69	3.75	Supported
$H1_8$	317.16	9	0	0.032	0.78	0.68	4.15	Supported
$H1_9$	218.63	8	0	0.040	0.93	0.72	5.56	Supported
$H1_{10}$	102.14	5	0	0.039	0.95	0.92	3.66	Supported

3.5 Results

The extent of implementation is determined by calculating the average mean score of six lean production practices in MET production area as mentioned earlier. A higher average mean value implies a higher degree of lean implementation. The results are shown in Table 7. The average mean scores were ranged from 3.89 to 3.77.

Specific equipment configurations are shown to be the highest implemented tool, with an average mean score of 3.89. The second highest ranked is total preventive maintenance (average mean score = 3.88) and the lowest ranked is new equipment/ technologies (average mean score = 3.77). The results are almost similar for each of the lean production practices.

Specific equipment configurations have the highest degree of implementation, thus indicating that the respondent companies are giving the highest priority to enhance their productivity by reduce the source of waste. Focusing on specific equipment configurations can help companies to achieve lean production goals (Shahin and Janatyan 2010).

The high degree of implementation of total preventive maintenance reveals that due to the increase in complexity of products/systems and rapid advances in technological innovation, performing maintenance actions for such products/systems now requires expensive equipments and special professional technicians, which is not economical for a company to keep. So most companies committed in cost reduction in order to achieve success in the initiative, support from management is crucial (Yeh et al. 2011).

The lowest adoption level of lean practices is for new equipment/ technologies, this might be due to many of the companies are being afraid from the effect of new equipment investment in decreasing a company's total factor productivity growth in

annual data (Huggett and Ospina, 2001). As a whole, the respondent companies are all very good) implementers of the six considered lean production principles. The overall average obtained is 3.84. The implementation level with comparison targets of the overall MET production area is shown in Figure 8.

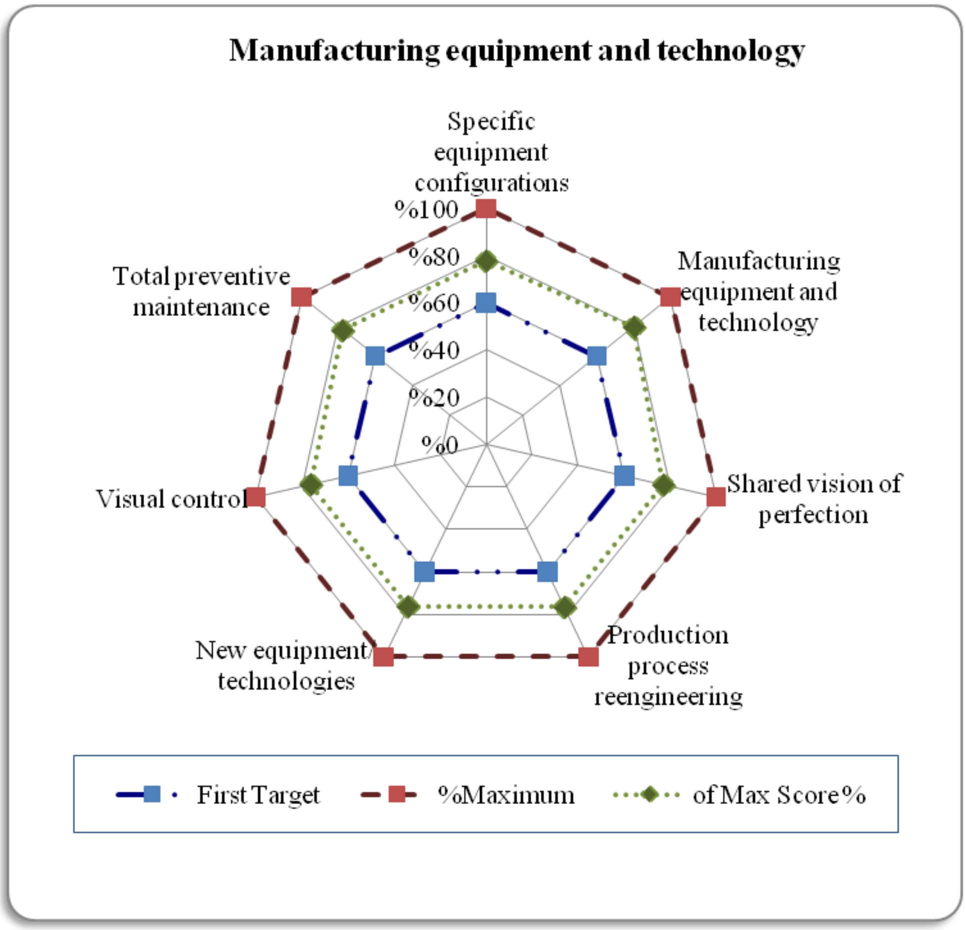

Figure 8 The implementation level with comparison to the targets for MET

The results for the correlation analysis of the developed model show that all the lean practices have a positive correlation with MET production area. Estimates of the relations for final developed model are shown in Figure 9. The estimated numbers indicate that when the implementation level of visual control goes up by 10%, over all implementation level of lean practices in MET production area goes up by 9.2%. Some estimated errors were high; this is an indication that further answers must be added to the questionnaire in order to validate this latent and thus reducing the estimated error.

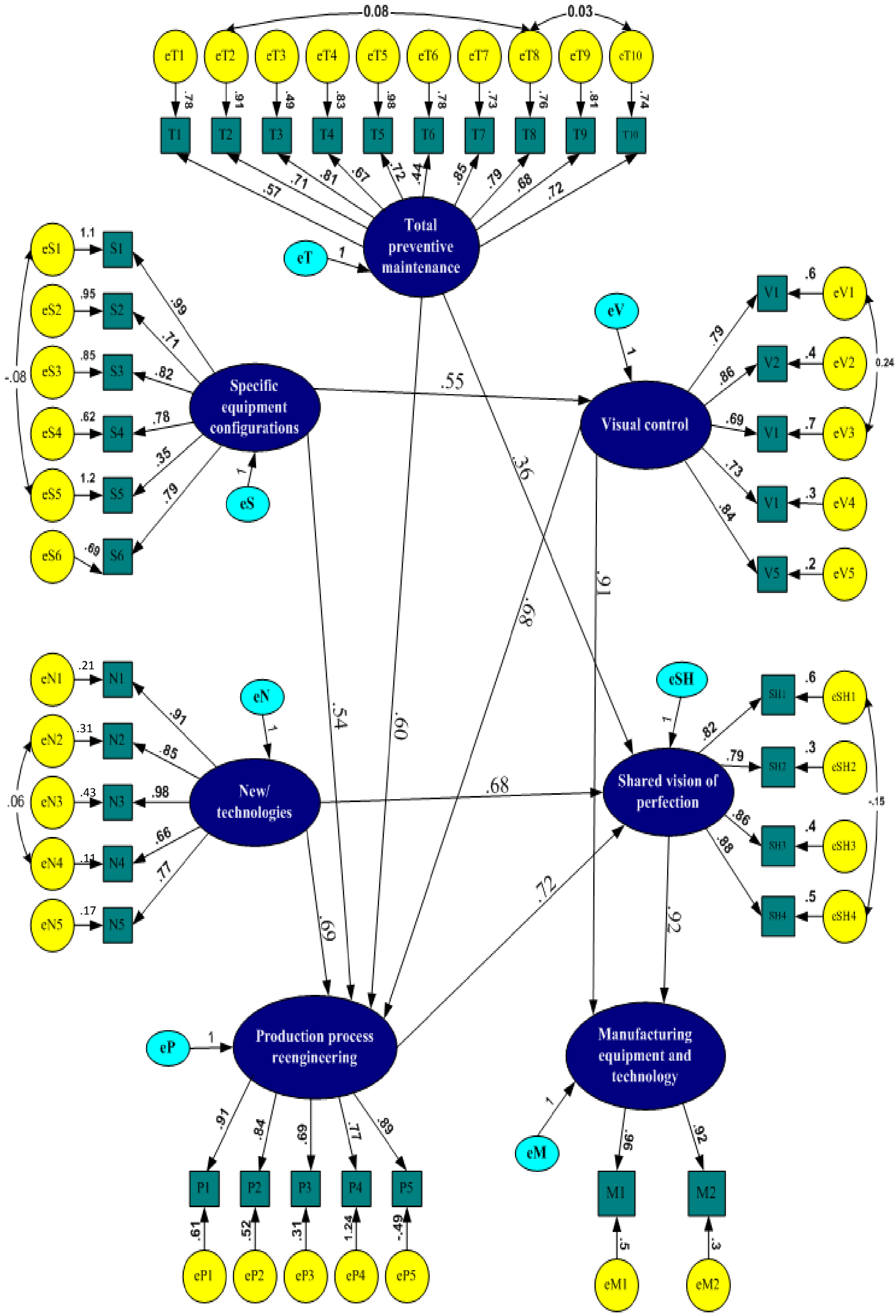

Figure 9 Estimates of the relations of the final developed model

Chapter Four
CONCLUSION, RECOMMENDATIONS AND FUTURE RESEARCH

This research was motivated by a desire to develop an assessment tool for the implementation of lean production principles in the Jordanian industries and to find out how MET production area is influenced by correlated lean practices. The finding that Jordanian companies are very good in the implementation of lean production principles offer results into these issues and provide concrete directions for future research and managerial guidelines.

This study extends the understanding of the implementation of six lean practices in MET production area. An empirical model is developed, hypotheses related to the six lean practices are assumed, investigated, and tested. Also the research provides an assessment lean tool that can successful evaluates the level of implementation of the considered lean tools in MET production area.

This research shed light on shared vision of perfection practice related to lean production implementation. As the importance of implementation of lean production principles, it is necessary for companies to understand that most of lean production practices are built in the company system even though the company is not implementing lean production and it is most advantageous to become proactive in their approach to lean production implementation.

Results indicate that lean production implementation appears to be more beneficial than costly when operating in competitive markets, and thus working with their employees toward the implementation of lean principles may be able to achieve enhanced performance gains. Alternatively, in markets where competitive intensity is high, companies need to understand the relative influence of lean production practices on the assessment of the implementation of them.

Further, one could argue that working toward the development of similar or compatible assessment tool for the implementation of lean principles in Jordanians companies can improve the effectiveness and ultimately the performance of such companies. On the other hand, the survey of this research is based on only one respondent from each company. Thus, the respondent's feedback may not reflect company policy or the view of other management level employees. Such personal bias may particularly affect answers made to questions, as answers tend to be subjective.

The research is conducted in a single country, i.e., Jordan. The restriction of data collection to a single country limits the generalization of the results. Thus, although we can argue that the theoretical model would hold in additional markets, future research can adequately address this issue.

Future research could investigate the implementation of lean production on other production area, such as processes technology, quality and productivity improvement and measures, production and inventory control, Shop floor management, product design and development, supplier relationship, customer relationship, workforce management, strategic management, etc.

In conclusion, this research investigated the implementation of six lean practices in the manufacturing equipment and technology (MET) production area in more than 200 Jordanian companies working in various sectors. An empirical model is formulated, proposed, and tested direct and relative influence of the six lean practices on each other and on the whole MET area is evaluated successfully.

The research provides a validated and tested assessment tool that help in improving progress and effectiveness of production processes improvement.

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APPENDIXES

APPENDIX 1

Survey cover letter
Development of an assessment tool for the implementation of lean production principles in the Jordanian industries

Dear Sir,

During the last decade, industry has been greatly affected by globalization, the economy, rising transportation costs, and changing buyer habits. Companies are working hard to stay cost competitive and to adapt to these changing market conditions. A critical part of companies' strive to adapt and become more competitive includes the use of management systems, such as, for example, lean production. Such systems have proven effective in helping leading companies to better performance and results. Lean production focuses on achieving short lead times, quick inventory turnovers, on-time delivery, built-in quality, high productivity, respect for all employees, and high customer satisfaction.

This research is conducting a development of an assessment tool for the implementation of Lean Production production principles in the Jordanian industries.
Thus, results from this survey will provide valuable information regarding lean production implementation practices and potential for improvement. Results will also help review and adapt services available to Jordanian industries to implement company-wide lean production performance improvements. We are asking for your help on this research by completing and returning the enclosed questionnaire.
Your company was chosen at random from a list of companies in Jordan. Since the number of participants is small, your response is vital for the success of this research. Please be assured that your response will be treated with complete confidentiality.
Thank you very much for your time and assistance. Should you have any questions, please contact me by (email) eng.shahnaz@yahoo.com.

Sincerely,

Eng. Shahnaz Alkhalil

APPENDIX 2

Survey questionnaire
Development of an assessment tool for the implementation of lean production principles in the Jordanian industries

Dear Respondent,

As part of my M.Sc. research at the University of Jordan, I am conducting a survey that investigates the implementation of lean production principles in the Jordanian industries. I will appriate it if you could complete the following questionnaire. Thank you very much for your cooperation.

Shahnaz Alkhalil (Researcher)
University of Jordan, Amman

Section (A): General Environment of the enterprise

1. Please mark your current position in the enterprise

a. General Manager   b. Quality Manger   c. Production Manager   d. Plant Manager
e. Production employee   f. Quality employee   h. Other (specify)……………….

2. Specify the type of your organization

a. Service (specify major service).......................
b. Manufacturing (specify one major product)………........

3. Specify industrial sector of your organization

a. Therapeutics and Medical	b. Plastic & rubber Products	c. Chemical and Cosmetics
d. Engineering, Electrical Industries and Information Technology	e. Furniture and Wooden	f. Construction
g. Packing, Packaging, Paper, Cartoon and Stationeries	h. Food, Supplies, Agricultural and Livestock	j. Leather and Garments
k. Mining	l. Micro-enterprises	m. Other (specify)……………….

Section (B): Lean production principles impact area

There are many lean production impact areas, one of them conducting in this research is: **Manufacturing equipment and technology**.

Please indicate the degree of implementation of each of the following practices in your Company, following the below rating scale:

(1) Poor; (2) Fair; (3) Good; (4) Very Good; (5) Excellent

Lean Production Impact Area: Manufacturing equipment and technology		Rating					Remarks
		1	2	3	4	5	
1.	**Specific equipment configurations (group technology, cellular layouts, continuous flow)**	1	2	3	4	5	
1.1	The equipment follows a documented procedure to control changes to configuration items/units.						
1.2	Changes in the definition of the product and its specific components are tracked and reported.						
1.3	Periodic audits are performed to verify that equipment baselines conform to the documentation that defines them (e.g., by the configuration group).						
1.4	Products are classified into groups with similar process requirements.						
1.5	Awareness of the variety of specific equipment configurations that can be utilized to improve the production process.						
1.6	Work cells have been developed and implemented to support specific product families and equipment configurations.						

Survey questionnaire- continue

		1	2	3	4	5	
2.	**Total preventive maintenance**						
2.1	The maintenance system is visible and easy to understand.						
2.2	Appropriate maintenance ways transferred to operators.						
2.3	All equipment maintain regularly.						
2.4	The formal preventive maintenance system is in place.						
2.5	Downtime for machine maintenance is scheduled.						
2.6	History for maintenance is kept.						
2.7	Maintenance personnel are alerted when major overhaul is required.						
2.8	Operators and Administrative staff take ownership of the equipment and are trained to carry out daily and weekly maintenance tasks						
2.9	Maintenance only performed when the machine breaks down.						
2.10	The operators (and office staff) are involved in the process of carrying out basic maintenance functions.						
3.	**Visual control**						
3.1	All materials are clearly identified.						
3.2	Use of color coded stack lights to visually communicate operating status of key equipment.						
3.3	Visual controls are utilized to display and communicate performance to stated goals and objectives.						
3.4	The organization uses a standard visual communication system throughout all work areas including offices.						
3.5	Visual controls are easy to understand and visitors can “read the workplace” with little help.						

Survey questionnaire- continue

		1	2	3	4	5	
4.	**New equipment/ technologies**						
4.1	You focus on minimizing development cost or developing products within a constrained budget.						
4.2	You turn to experts for advice about new technology.						
4.3	You offer one-on-one or classroom-based technology training.						
4.4	You focus on having the highest level of product performance, the highest level of functionality or functions and features.						
4.5	You focus on having the latest technology or the highest level of product innovation.						
4.6	Your procedures and policies with relation to updated information about new equipment or technologies are available.						
5.	**Production process reengineering**						
5.1	Process focuses on simplification and elimination of wasted efforts.						
5.2	Process is designed to achieve dramatic improvements in critical contemporary measures of performance, such as cost, quality, service, and speed.						
5.3	Analysis and design of workflows and processes are done within and between organizations.						
5.4	Teams redesign the way work is done to better support the organization's mission and reduce costs.						
5.5	Managers allow change, new revolutionary ideas to evolve.						

Survey questionnaire- continue

		1	2	3	4	5	
6.	**Shared vision of perfection**						
6.1	Managers will create an environment in which mistakes are tolerated.						
6.2	Managers believe that improvements and change are never complete.						
6.3	Managers give feed back to teams and individuals all the time.						
6.4	Managers accept that there are probably better ways of performing a process operation.						
7.	**Manufacturing equipment and technology**						
7.1	Your strategy involves higher risks with newer technologies and accepts a trade-off of time and cost to pursue your objectives.						
7.2	There is a plan to measure the effectiveness of the new technology process.						

APPENDIX 3
Experts' revision and feedback for the questionnaire

RE: Questionnaire pretest

From: "Raad Nassar"

To: "Shahnaz"

Cc: "Mahmoud Al-Ardah"

1 File (53KB)

Developme

Dear Shahnaz,

I've reviewed the survey and found it comprehensive and clear. I have some minor comments highlighted in the attached document.

Good luck ..

Best Regards,

Raad Nassar (Eng) - PMP, PHR
Assistant Consulting Manager

Talal Abu-Ghazaleh & Co. Consulting (TAG-Consultants), Member of Talal Abu-Ghazaleh Organization (TAGorg)
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Mob: +962 7 95116130
Fax: +962 6 5100601

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RE: Questionnaire pretest

From: "Anas khasawneh"

To: "'Shahnaz'"

Cc: "Anas Khasawneh"

Dear Eng. Shahinaz

Regarding the questionnaire I filled, it is very clear and touches important aspects of the industry which are not tackled in everyday even they occurs every day.

Good luck.

Best Regards

Eng. Anas Khasawneh
Industrial Development Department Manager
Jordan Chamber of Industry

Tel: + 962 6 4642649 EX 570
Fax: + 962 6 4643719
Cell: + 962 79 6341133

APPENDIX 4
Companies participated in the survey

No.	Company Name	E-mail
1	Dar Aldawa Development&investment Co.ltd	admin.dad@dadgroup.com
2	Hikma Pharmaceuticals Co.	alghoulh@hikma.com
3	Spartan Modern Industry Co.	info@spartan.com.jo
4	Al Sughier Ind. Co.	sughayer@nets.com.jo
5	Kilani Medical Industries Co.	info@kilanimedical.com
6	Al E'temad Chemical Ind. Co. "chemanz"	kh-ashour@hotmail.com
7	Natural Mineral Dead Sea Salts Est.	madifurn@joinnet.com.jo
8	Kinz Health Care Est.	kinshealthcare@gmail.com
9	The Arab Pharmaceutical Mfg. Co.	apm@go.com.jo
10	Ram Pharmaceuticals Ind. Co.	info@ram_pharma.com
11	Efada Medical Industries Co.ltd	sutcon@sutcon.net
12	Delass Natural Products	jtm@go.com.jo
13	Al Amin Medical Ind. & Supplies Co.	amicosales@batelco.jo
14	Alfa Chemicals Manufacturing Establishment	bbitar.alfa@batelco.jo
15	Venus Chemicals Est.	info@venusdetergents.com
16	Jerash Pharmaceuticlas	jerash@khraim.com
17	Al-qareb Chemicals Ind.	yznest@yahoo.com
18	Duha For Chemical Industries Co.	duhachem@hotmail.com
19	Sana Pharmaceutical Research Co	info@sana-pharma.com
20	Al Rahma Pharmaceutical Industry Co.ltd.	rah@techni-qroup.com
21	The United Pharmaceuticals Ind.co.	info@femigiene.net
22	Dar Alqimmah For Manufacturing Cosmetics Products	natural_deadsea@yahoo.com
23	National Plastic Footwear Mfg. Co.	contact@med-ind.net
24	Petra Plastic Co.	info@sandmplastic.com
25	Orient Plastic Co.	opc@nets.com.jo
26	Al Fajer Plastic Fac.	emaddiab6z@hotmail.com
27	The Engineering Plastic Ind. Co.	engplast@wanadoo.jo
28	Al Kaser Ind. Est.	qaser@index.com.jo
29	Al Naser Plastic Fac.	nasrplst@yahoo.com
30	Al ansar Plastic Ind.	ansarco@yahoo.com
31	Idealism Co. For Curtains Systems	kalid_rahman@yahoo.com
32	Ard Al-rumman Plastic Mfc.co.	mohd-romman@hotmail.com
33	Al Sughier & Marar Plastic Ind. Co.	info@sandmplastic.com
34	Intermediate Petrochemicals Ind. Co.	ipi@wanadoo.jo
35	Arab Foam Fac. Co.	arabfoam@nuqulgroup.com
36	International Plastic & Wood Mfg. Co.	interplastjordan@gmail.com
37	Al Ahli Plastic Fac. Co.	info@apf.com.jo
38	Elba House Co.	elba@go.com.jo
39	Jerusalem Plastic Co.	naji@gmail.com
40	International Plastic Ind. Est.	ousama@iplasticd.com
41	Al Shaker Plastic Ind. Est.	shaker-gh@hotmail.com

Companies participated in the survey- continue

No.	Company Name	E-mail
42	Golden Star Plastic Fac.	info@goldemstarfactory.jo
43	Jordan Chemical Products Co.	hfaris@jipco.com.jo
44	Alfa Chemicals Manufacturing Establishment	bbitar.alfa@batelco.jo
45	Hammoudeh Trade & Ind. Est.	info@hamoudeh.jo
46	Alzara Natural Dead Sea Products	zaraprod@go.com.jo
47	Medicare (jordan)	medicare@accessme.com
48	National Chlorine Ind. Co.	info@chlorine.com.jo
49	Universal Ind. Co.ltd	zalloum@zalloumgroup.com
50	Universal Chemical Ind. "plc"	uci@go.com.jo
51	The Arab Potash Co.	info@arabpotash.com
52	Jordan Gases Co.	nksc@nets.com.jo
53	United Chemical Co. Ltd.	info@unichemgroup.com
54	Al Wafa' Plastic Ind. & Commercial Est.	wafaplas@go.com.jo
55	Arab Lands Chemicals Co.	bajjali@nets.com.jo
56	Paints & Chemicals Co.	ipc@nol.com.jo
57	Spartan Modern Industry Co.	info@spartan.com.jo
58	Philadelphia Paints Fac.	philadelphia@orange.jo
59	National Gas Ind. Co. Ltd.	nagas@nets.com.jo
60	Areen Chemical Ind.	info@areen-jo.com
61	The Jordan Match Co.	asfourco@nets.com.jo
62	Istanbul Soap Manufactoring	amani@lotusjordan.com
63	Rum-aladdin Ind. Co.	tareq@rum_aladdin.com
64	Manneh Industrial Group	jnfc@manneh.com.jo
65	Ayoubi's Steel Furniture Factory Co.	info@ayoubi.com
66	Al Dar Glass Ind. Co.	info@aldarglass.com
67	Waddah Hariz Goldsmith Fac.	waddah@hreiz.com
68	Arabian Est. For Rubber Ind.	info@arabthane.com
69	Shahrouri Est. Solar Sun Heaters&building Material	shahmfjco@index.com.jo
70	Metal Ind. Co.	suzi@matelco.com
71	Jordan Aluminium Plating & Mfg. Co.	askaval@orange.jo
72	Technological Ind. Group Co.	info@tig_jo.com
73	Jordanian Electric Power Co. Ltd. Amman	jepco@go.com.jo
74	National Foam Fac .	sameeh@nationalfoam.org
75	Masri Bros. Co.	info@masribrothers.com
76	Elba House Co.	elba@go.com.jo
77	Shadi Aluminum Kitchen Wares Factory	naimk@go.com.jo
78	Jordan Phosphate Mines Co. Ltd.	info@jpmc.com.jo
79	Arabian Est. For Rubber Ind.	info@arabthane.com
80	Halawani Industrial Company	info@hic.jo
81	Negem Co. For Engineering & Contracting	info@nejemco.com
82	Jordan Petroleum Refinery Co. Ltd.	addewan@jopetrol.com.jo
83	International Plastic & Wood Mfg. Co.	interplastjordan@gmail.com

Companies participated in the survey- continue

No.	Company Name	E-mail
84	Ra'ed Albzlamit For Carpentry Works	Raedbazlamit@hotmail.com
85	Ayoubi's Steel Furniture Factory Co.	info@ayoubi.com
86	Ala'aeden Est. Wooden & Decoration Works	aladdincd@yahoo.com
87	Al Noor Carpentry Co.	saadadeen@yahoo.com
88	The Modern Chandeliers Ind. Co.	jako@nets.com.jo
89	Selection Wood Ind.	info@babtechjo.com
90	Petra Aluminium Company Ltd.	heba@petralu.com
91	Lebanon Furniture Co.	issa@lfco.com.jo
92	Ali Al-jamal Co. & Partner's	aljamal39@yahoo.com
93	Abdullah Al Assaf Technical Carpentry	abcicl_ulla_assar@yahoo.com
94	Al Ferdous Carpentry Workshop.	aalamedan@hotmail.com
95	Jordan Wood Industries. Co.ltd (jwico)	adm@jwico.com
96	Specialized Furniture Est/maani&partners Furniture	maani@maani.com
97	Forum Furniture Co. W.l.l	suzi@matelco.com
98	American Kitchen Co. L.t.d	amkit@go.com.jo
99	Jamil Sahouri & Bros. Co.	sahouri@go.com.jo
100	Al-mi'mari Trade&industry Est.	factory@al-mimari.com
101	Jordan Furniture Ind. Est.	jordanian.industuries@hotmail.com
102	Arabesque Marble & Granite	arabisc@hotmail.com
103	Ayoubi's Steel Furniture Factory Co.	info@ayoubi.com
104	Najeeb Zreikat Sons&partners Co	zreikat@index.com.jo
105	Ala'aeden Est. Wooden & Decoration Works	aladdincd@yahoo.com
106	Antoine Kayyal & Sons Co.	ykayyal@hotmail.com
107	The Modern Chandeliers Ind. Co.	jako@nets.com.jo
108	Selection Wood Ind.	info@babtechjo.com
109	Al Faisal Ind. Co.	alfaisal@index.com.jo
110	Lebanon Furniture Co.	issa@lfco.com.jo
111	American Kitchen Co. L.t.d	amkit@go.com.jo
112	Al-mi'mari Trade&industry Est.	factory@al-mimari.com
113	Jordan Greenhouses Manufacturing Company Limited	info@rayyan.com.jo
114	Jordan Furniture Ind. Est.	jordanian.industuries@hotmail.com
115	Universal Wood Working Ind. Co .	bkubbah@yahoo.com
116	Tahboub Bros. Wood Industry	kitchens@tahbaub.org
117	Arabian Company For Manufacturing Formica&woods	sysjo@go.com.jo
118	Petra Aluminium Company Ltd.	heba@petralu.com
119	Jaref Alsaker Co For Woods Works	i_joinery@yahoo.com
120	Specialties Co For Spring Mattresses Ind	saleembata@yahoo.com
121	Attanqeeb Construction Materials Mfg. Co	atanqeeb@wanadoo.jo
122	Asees Fac. For Marble & Stone	asqis_marble.stone@yahoo.com
123	Al Najah Marble & Tiles Fac.	alnajah_marble@yahoo.com
124	Petra Stones & Marble Est.	petrastone@hotmail.com

Companies participated in the survey- continue

No.	Company Name	E-mail
125	The Castle Fac For Mineral Industiral&fire Doors	albassamadoors@hotmail.com
126	Mohammad Shahen&ashraf Alsaede Co	hamzealord2009@live.com
127	Omayya Marbles & Granite Co.	info@ammayamarble.com
128	Al Abjar For Solid Surfaces Fabrication	rweished57@gmail.com
129	Samir Afaneh For Bricks&tiles Fac.	s.afaneh@yahoo.com
130	Masa Chemical Ind Co	buffco@aim.ae
131	Shaher For Stone &marble Fac.	nezarshaher@yahoo.com
132	Shaher For Stone &marble Fac.	saudI.jo.cement@orange.jo
133	Al Mukhtar Construction Materials Mfg. Co	info@mukhtargroup.com
134	Oversease Factory For Producing Porcelain Tiles Co	smart.target@hotmail.com
135	Alrawnaq For Metal Forming Co.	ahmad.alhallaq@gmail.com
136	Kan'an Land Industriel Co.	nass_issa@hotmail.com
137	Taybah Metal Industries Co.	fanassana@yahoo.com
138	Stars Ground Industirl Est.	awniabo@yahoo.com
139	Alraqim For Stone&mrble Co.	pcejordan@yahoo.com
140	Alnafitha Company For Aluminum&glass Ind	alnafitha@alhusseinigroup.com
141	The Jordanian Printing Press	jopress@go.com.jo
142	Al Shabab Printing Press	shababpress@maktoob.com
143	Modern Fuhies Printing Press	fpp@wanadoo.jo
144	Grand Paper Bags Fac&printers	shammoutco.wasfef@yahoo.com
145	The Economic Press Co .	print@economicpress.net
146	Jordan Ice & Aerated Water Co.	nidal.hamam@intl.papesico.com
147	Saba & Nassar & Partners Printing Co.	nassar4@zaindats.com
148	Al Tally Trading & Ind . Co	batajoco@bata.jo
149	Jordan Petroleum Refinery Co. Ltd.	addewan@jopetrol.com.jo
150	Metro Printing And Card Board Boxes Co.	info@metrojo.com
151	The Cooperative Printing Presses Workers	m.option@hotmail.com
152	Union Printing Press Co.	unionprintingpress@yahoo.com
153	Al Nahdah Printing Press Co.	INFO@nahdapress.com
154	Al Yarmouk Printing Press	ghzemad@hotmail.com
155	Central Press	info@centralpress.jo
156	Paper Converting & Stationery Ind. Est.	hazin@giocities.com
157	Al Noor Printing Press	alnoor_printingprees@doosa.jo
158	Bibars Ind. Est.	bibars@nets.com.jo
159	Fine Hygienic Paper Co. Ltd	fineinquiry@fine.nuqul.com.jo
160	The Flame Graphic Arts Center	flame@cyberia.jo
161	Petra Trading & Investment Co.	a.zaidat@petragroup.com.jo
162	Abdulazeem Sharawi & Brothers Co.	info@sharawi-gum.com
163	The Modern Flour Mills & Macaroni Fac.	modmills@go.com.jo
164	Jordan Feed Co. Ltd.	jordanfeed@hammoudeh.com
165	Al-karawan Confectionery Co . Llc	jfpf@nets.com.jo
166	Al-karawan Confectionery Co . Llc	aci@al-karawan.com

Companies participated in the survey- continue

No.	Company Name	E-mail
167	The Jordan Venus Factories Co.	venuschocolates@aol.com
168	Agricultur. Marketing&proces. Co."ampco"	ampco@go.com.jo
169	Gulf Resources Food Ind. Co.	gulfres@accessme.co
170	New Nahda Oil Press Co.	nahda@go.com.jo
171	National Hatchery Co. Ltd.	feed@hammoudah.com
172	Al-qaria Food&vegetable Oil Ind.co	info@qarya.jo
173	Ghadeer Mineral Water Co.	info@nestle-waters.com.jo
174	Arab Food Ind. Co.	info@noonfoods.com
175	Zakey Industrid Co.	info@zakeyinc.com
176	Subhi Jabri & Sons Co.	info@jabri.com.jo
177	Nazmi Subeih Food Factory	nazmi@subeih.com
178	Arabian Trade & Food Ind. Co.	info@arabian-food.com
179	Jordan Valley Food Ind. Co.	albayrouty@yahoo.com
180	Danish Jordanian Dairy Co.	danish@nets.com.jo
181	Philadelphia Mineral Water Co.	info@ati-jo.com
182	Jordan Rubber Ind. Co.	nassar4@zaindata.com
183	The Jordan Worsted Mills Co. Ltd.	worsted@firstnet.com.jo
184	Jordan Clothing Co.	cjc@jccjo.com
185	National Textiles Est.	tnahar@go.com.jo
186	Mondial Tricot & Socks Ind. Co.	haqqie@hotmail.com
187	Daleh For Trade And Industry Shose	hasan_mujahed@hotmail.com
188	Al-kamal Ready Mad Clothes Fac.co.	mohy_homsi@hotmail.com
189	National Grament's And Denim Mills	ngdm2@hotmail.com
190	Al Nahda Socks Fac. Co.	nahdasocks57@hotmail.com
191	Al Sharq Tricot Fac.	mohd_tawilleh@yahoo.com
192	Universal Tricot Fac.	nsinokrot@hotmail.com
193	The Jordan Tricot & Yarn Fac. Co.	jtyco@wanadoo.jo
194	National Plastic Footwear Mfg. Co.	contact@med-ind.net
195	National Co. Socks & Tricot & Shirts	attar.co@index.com.jo
196	The Jordan Al-manara Shoes Co.	maha@jordanalmanara.com
197	Jerusalem Textiles & Cotton Ind. Fac.	jitan@go.com.jo
198	Crocodile Ind. Est.	elraed@batelco.jo
199	Global Carpet & Rug Ind. Co.	gcr@tedata.net.jo
200	Dana Tricot & Weaving Est.	ammabutar@hotmail.com

Companies participated in the survey- continue

No.	Company Name	E-mail
201	Al Mashrek Socks Fac.	mazhar@tellosocks.com
202	Stars Hosiery Mfg. Co.	stars@nets.com.jo
203	The General Mining Co. Ltd.	gm@minco_jo.com
204	Jordan Cement Fac. Co. Ltd.	cement.info@jordan.laverte.com
205	Arab Co. For White Cement Ind.	info@acwci.com
206	Talal Abu-Ghazaleh & Co. Consulting	rnassar@tag-consultants.com
207	United Bros.for Marble&building Stone Co	info@ubco.com.jo
208	Numeira Mixed Salts & Mud Co.	info@numeira.com.jo
209	Jordan Magnesia Company Ltd.	jormag@ORANG.jo

APPENDIX 5
MET model correlation matrix

MET model Correlation Matrix

	S1	S2	S3	S4	S5	S6	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	V1	V2	V3	V4	V5	N1	N2	N3	N4	N5	N6	P1	P2	P3	P4	P5	SH1	SH2	SH3	SH4	M1	M2
S1	1.0	0.3	0.2	0.1	0.1	0.2	0.3	-0.1	0.1	0.1	0.4	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.0	0.1	0.0	0.1	0.0	0.1
S2	0.3	1.0	0.0	0.3	0.1	0.0	0.2	0.0	0.1	0.0	0.2	0.4	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	-0.1	0.1	0.0	0.1	-0.1	0.1	-0.1	0.1	-0.1	0.1	0.1
S3	0.2	0.0	1.0	0.4	0.1	0.1	0.1	-0.1	0.4	0.0	0.3	0.1	0.3	0.1	0.1	0.2	0.1	0.0	-0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.0	-0.1	0.1	0.1	0.2	-0.1	0.2	0.0	0.2	-0.1	0.2	0.0	0.0
S4	0.1	0.3	0.4	1.0	0.0	0.1	0.2	0.0	0.3	-0.1	0.3	0.2	0.0	0.1	0.0	0.1	0.1	0.1	-0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.1
S5	0.1	0.1	0.1	0.0	1.0	0.3	0.1	-0.1	0.0	-0.1	0.0	0.0	0.0	0.4	0.3	0.3	0.3	0.3	0.2	0.4	0.1	0.4	0.3	0.3	0.3	0.3	0.2	0.4	0.1	0.9	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
S6	0.2	0.0	0.1	0.1	0.3	1.0	0.1	0.0	-0.1	0.0	0.1	0.0	0.1	0.3	0.5	0.2	0.3	0.0	-0.1	0.3	0.2	0.3	0.5	0.1	0.2	0.0	-0.1	0.3	0.1	0.3	-0.1	0.4	0.9	0.3	0.4	0.2	0.2	0.1
T1	0.3	0.2	0.1	0.2	0.1	0.1	1.0	0.3	0.2	0.2	0.3	0.1	0.3	0.1	0.1	0.2	0.1	0.3	0.1	0.2	0.1	0.2	0.1	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.0	0.2
T2	-0.1	0.0	-0.1	0.0	-0.1	0.0	0.3	1.0	0.1	0.1	0.1	-0.1	0.0	0.1	0.0	-0.1	0.0	0.1	0.1	-0.1	0.0	0.1	0.0	-0.1	0.0	0.1	0.1	-0.1	0.0	-0.1	0.1	-0.2	0.0	0.0	0.1	-0.1	0.0	0.1
T3	0.1	0.1	0.4	0.3	0.0	-0.1	0.2	0.1	1.0	0.2	0.3	0.2	0.2	0.0	-0.1	0.2	0.1	0.2	-0.1	0.0	0.0	0.0	-0.1	0.2	0.1	0.1	0.0	0.1	0.0	0.0	-0.2	0.0	-0.1	-0.1	0.0	0.2	0.1	0.2
T4	0.1	0.0	0.0	-0.1	-0.1	0.0	0.2	0.1	0.2	1.0	0.1	0.1	0.1	-0.1	-0.1	0.1	0.0	0.0	-0.1	0.1	0.1	0.0	-0.1	0.1	0.0	0.0	-0.1	0.1	0.1	-0.1	0.0	0.0	0.0	-0.1	-0.1	0.1	0.0	0.0
T5	0.4	0.2	0.3	0.3	0.0	0.1	0.3	0.1	0.3	0.1	1.0	0.2	0.2	0.1	0.0	0.2	0.2	0.1	-0.1	0.2	0.2	0.1	0.0	0.2	0.2	0.0	0.0	0.1	0.1	0.1	0.0	0.3	-0.1	0.1	-0.1	0.1	0.1	0.1
T6	0.2	0.4	0.1	0.2	0.0	0.0	0.1	-0.1	0.2	0.1	0.2	1.0	0.1	0.0	0.0	0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	0.0	-0.1	-0.1	0.0	0.0	0.1	0.0	0.0
T7	0.2	0.0	0.3	0.0	0.0	0.1	0.3	0.0	0.2	0.1	0.2	0.1	1.0	0.0	0.1	0.1	0.1	0.0	-0.2	0.1	0.2	0.1	0.2	0.1	0.1	-0.1	-0.1	0.1	0.1	0.0	-0.2	0.1	0.0	0.2	0.0	0.1	0.0	-0.1
T8	0.1	0.0	0.1	0.1	0.4	0.3	0.1	0.1	0.0	-0.1	0.1	0.0	0.0	1.0	0.4	0.1	0.2	0.3	0.0	0.3	0.0	0.9	0.4	0.1	0.1	0.3	0.0	0.2	0.1	0.4	0.0	0.2	0.3	0.8	0.4	0.1	0.2	0.3
T9	0.2	0.0	0.1	0.0	0.3	0.5	0.1	0.0	-0.1	-0.1	0.0	0.0	0.1	0.4	1.0	0.1	0.2	0.2	-0.1	0.2	0.0	0.4	1.0	0.1	0.2	0.2	-0.1	0.2	0.0	0.4	-0.1	0.2	0.4	0.4	0.9	0.1	0.2	0.2
T10	0.1	0.0	0.2	0.1	0.3	0.2	0.2	-0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	1.0	0.5	0.1	0.0	0.5	0.1	0.2	0.1	1.0	0.5	0.1	0.1	0.5	0.1	0.3	0.0	0.4	0.2	0.1	0.1	0.9	0.5	0.1
V1	0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.0	0.1	0.0	0.2	0.0	0.1	0.2	0.2	0.5	1.0	0.2	-0.1	0.4	0.0	0.2	0.2	0.5	0.9	0.1	0.0	0.3	0.0	0.3	0.0	0.3	0.2	0.1	0.3	0.6	0.9	0.1
V2	0.1	0.1	0.0	0.1	0.3	0.0	0.3	0.1	0.2	0.0	0.1	0.0	0.0	0.3	0.2	0.1	0.2	1.0	0.4	0.3	0.2	0.4	0.2	0.2	0.2	1.0	0.4	0.3	0.2	0.3	0.3	0.2	0.1	0.2	0.2	0.1	0.2	0.9
V3	0.1	0.1	-0.2	-0.1	0.2	-0.1	0.1	0.1	-0.1	-0.1	-0.1	-0.1	-0.2	0.0	-0.1	0.0	-0.1	0.4	1.0	-0.1	0.0	0.0	-0.1	0.0	0.0	0.4	1.0	0.0	0.0	0.1	0.9	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.4
V4	0.1	0.0	0.2	0.0	0.4	0.3	0.2	-0.1	0.0	0.1	0.2	0.0	0.1	0.3	0.2	0.5	0.4	0.3	-0.1	1.0	0.4	0.3	0.2	0.4	0.3	0.2	0.0	0.9	0.3	0.5	0.1	0.8	0.3	0.2	0.2	0.5	0.3	0.2
V5	0.2	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.2	0.0	0.2	0.0	0.0	0.1	0.0	0.2	0.0	0.4	1.0	0.1	0.0	0.1	0.0	0.2	0.1	0.3	0.9	0.1	0.1	0.4	0.1	0.1	-0.1	0.0	0.0	0.1
N1	0.1	0.0	0.1	0.1	0.4	0.3	0.2	0.1	0.0	0.0	0.1	0.0	0.1	0.9	0.4	0.2	0.2	0.4	0.0	0.3	0.1	1.0	0.4	0.2	0.2	0.4	0.1	0.3	0.1	0.4	0.0	0.2	0.3	0.8	0.4	0.1	0.2	0.3
N2	0.2	0.0	0.1	0.0	0.3	0.5	0.1	0.0	-0.1	-0.1	0.0	0.0	0.2	0.4	1.0	0.1	0.2	0.2	-0.1	0.2	0.0	0.4	1.0	0.1	0.3	0.2	0.0	0.2	0.0	0.3	-0.1	0.2	0.4	0.5	0.9	0.1	0.2	0.2
N3	0.0	0.0	0.2	0.1	0.3	0.1	0.3	-0.1	0.2	0.1	0.2	0.0	0.1	0.1	0.1	1.0	0.5	0.2	0.0	0.4	0.1	0.2	0.1	1.0	0.6	0.2	0.1	0.5	0.1	0.3	0.0	0.4	0.2	0.1	0.1	0.9	0.5	0.1
N4	0.1	0.1	0.1	0.1	0.3	0.2	0.2	0.0	0.1	0.0	0.2	-0.1	0.1	0.1	0.2	0.5	0.9	0.2	0.0	0.3	0.0	0.2	0.3	0.6	1.0	0.2	0.0	0.4	0.0	0.3	0.0	0.3	0.2	0.2	0.3	0.5	0.9	0.1
N5	0.0	0.1	0.0	0.1	0.3	0.0	0.2	0.1	0.1	0.0	0.0	0.0	-0.1	0.3	0.2	0.1	0.1	1.0	0.4	0.2	0.2	0.4	0.2	0.2	0.2	1.0	0.4	0.3	0.1	0.3	0.3	0.1	0.1	0.2	0.2	0.1	0.2	0.9
N6	0.1	0.1	-0.1	0.0	0.2	-0.1	0.2	0.1	0.0	-0.1	0.0	0.0	-0.1	0.0	-0.1	0.1	0.0	0.4	1.0	0.0	0.1	0.1	0.0	0.1	0.0	0.4	1.0	0.1	0.1	0.2	0.9	0.0	-0.1	0.0	0.0	0.0	0.0	0.4
P1	0.1	-0.1	0.1	0.1	0.4	0.3	0.2	-0.1	0.1	0.1	0.1	-0.1	0.1	0.2	0.2	0.5	0.3	0.3	0.0	0.9	0.3	0.3	0.2	0.5	0.4	0.3	0.1	1.0	0.3	0.4	0.0	0.8	0.2	0.2	0.2	0.4	0.3	0.3
P2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.2	0.0	0.3	0.9	0.1	0.0	0.1	0.0	0.1	0.1	0.3	1.0	0.2	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.1
P3	0.1	0.0	0.2	0.1	0.9	0.3	0.1	-0.1	0.0	-0.1	0.1	0.0	0.0	0.4	0.4	0.3	0.3	0.3	0.1	0.5	0.1	0.4	0.3	0.3	0.3	0.3	0.2	0.4	0.2	1.0	0.2	0.4	0.2	0.4	0.3	0.3	0.2	0.3
P4	0.1	0.1	-0.1	0.0	0.2	-0.1	0.1	0.1	-0.2	0.0	0.0	0.0	-0.2	0.0	-0.1	0.0	0.0	0.3	0.9	0.1	0.1	0.0	-0.1	0.0	0.0	0.3	0.9	0.0	0.1	0.2	1.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.3
P5	0.2	-0.1	0.2	0.0	0.3	0.4	0.1	-0.2	0.0	0.0	0.3	-0.1	0.1	0.2	0.2	0.4	0.3	0.2	-0.1	0.8	0.4	0.2	0.2	0.4	0.3	0.1	0.0	0.8	0.3	0.4	0.0	1.0	0.2	0.2	0.1	0.4	0.2	0.2
SH1	0.0	0.1	0.0	0.1	0.3	0.9	0.1	0.0	-0.1	0.0	-0.1	-0.1	0.0	0.3	0.4	0.2	0.2	0.1	-0.1	0.3	0.1	0.3	0.4	0.2	0.2	0.1	-0.1	0.2	0.1	0.2	-0.1	0.2	1.0	0.2	0.5	0.1	0.2	0.0
SH2	0.1	-0.1	0.2	0.0	0.3	0.3	0.2	0.0	-0.1	-0.1	0.1	0.0	0.2	0.8	0.4	0.1	0.1	0.2	-0.1	0.2	0.1	0.8	0.5	0.1	0.2	0.2	0.0	0.2	0.0	0.4	-0.1	0.2	0.2	1.0	0.3	0.1	0.1	0.2
SH3	0.0	0.1	-0.1	0.1	0.3	0.4	0.1	0.1	0.0	-0.1	-0.1	0.0	0.0	0.4	0.9	0.1	0.3	0.2	-0.1	0.2	-0.1	0.4	0.9	0.1	0.3	0.2	0.0	0.2	0.0	0.3	-0.1	0.1	0.5	0.3	1.0	0.1	0.2	0.3
SH4	0.1	-0.1	0.2	0.1	0.3	0.2	0.2	-0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.9	0.6	0.1	0.0	0.5	0.0	0.1	0.1	0.9	0.5	0.1	0.0	0.4	0.0	0.3	0.0	0.4	0.1	0.1	0.1	1.0	0.5	0.1
M1	0.0	0.1	0.0	0.0	0.3	0.2	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.2	0.2	0.5	0.9	0.2	0.0	0.3	0.0	0.2	0.2	0.5	0.9	0.2	0.0	0.3	0.0	0.2	0.0	0.2	0.2	0.1	0.2	0.5	1.0	0.1
M2	0.1	0.1	0.0	0.1	0.3	0.1	0.2	0.1	0.2	0.0	0.1	0.0	-0.1	0.3	0.2	0.1	0.1	0.9	0.4	0.2	0.1	0.3	0.2	0.1	0.1	0.9	0.4	0.3	0.1	0.3	0.3	0.2	0.0	0.2	0.3	0.1	0.1	1.0

تطوير أداة لتقييم مدى تطبيق مبادئ الإنتاج المرن والكفؤ في الصناعات الأردنية

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ملخص

البقاء في سوق عالمي تحركه قوى تخضع للتغيير المستمر، يتطلب من الشركة الصناعية أن تحرز قدم السبق على منافسيها. لذلك أضحى تحسين المنتجات و تحسين عمليات الإنتاج ضرورة أكثر من أي وقت مضى. الإنتاج المرن والكفؤ واحد من هذه المتطلبات التي تساهم في تحسن عمليات الإنتاج من خلال تقليل الهدر بكل أنواعه إلى الحد كوقت الانتظار، و مستوى التخزين، و نسبة المرفوض و غيرها.

يمكن تقسيم مجالات تطبيق مبادئ الإنتاج المرن والكفؤ إلى مجالات متعددة. من هذه المجالات، مجال تصنيع المعدات والتكنولوجيا. يمكن توزيع مبادئ الإنتاج المرن و الكفؤ في هذا المجال إلى ستة أدوار تشمل التوزيع المحدد للمعدات، والصيانة الوقائية الشاملة، والمراقبة المرئية، تجديد المعدات والتكنولوجيا، وعمليات إعادة الهيكلة بالإضافة إلى الرؤية التشاركية للإتقان.

الغرض من هذه الدراسة التعرف على مستوى تطبيق أدوات ومبادئ الإنتاج المرن والكفؤ في الصناعات الأردنية .لتحقيق ذلك تم تصميم استبيان وفقا لمقياس ليكرت من خمس نقاط، ومن أجل التحقق من صحة الاستبيان أجريت دراسة تجريبية لحوالي 25 شركة وقام خبراء بمراجعته. كانت العينة من الشركات الأردنية التي استجابت للدراسة 209 بمعدل الاستجابة كان 59٪ (350/209).

طلب من الشركات المشمولة بالدراسة تقييم معدل تطبيق أدوات الإنتاج المرن والكفؤ. تم حساب متوسط النقاط لكل أداة، وأجريت بعد ذلك بعض التحليلات الإحصائية. وتم تطوير نموذج هيكلي للدراسة وبنيت فرضيات له، ثم أجري اختبار أنوفا الإحصائي عليه. كذلك تم تطوير أداة تقييم لتطبيق أدوات الإنتاج المرن والكفؤ لتساعد في رصد التقدم المحرز في الإنتاج وفعاليته في تحسين جهود الشركة العملية.

أظهرت نتائج الدراسة أن مستوى تطبيق أدوات الإنتاج المرن كان 76.86% في مجال الدراسة، وأن تطبيق الشركات الأردنية لهذه الأدوات جاء جيد جدا، و مستوى توافق لعناصر الدراسة بلغت 87% حيث تم قياس ذلك بمعيار كرونباخ α وهذه النتيجة تعتبر جيدة جدا. يمكن أن تستخدم أداة التقييم لتطبيق أدوات الإنتاج المرن والكفؤ لتحديد الثغرات في أداء الشركة وإنتاجها، وفرصة لتحسين أي تقدم في إنتاج الشركة.